Metallurgical and Chemical Engineering

A Consolidation of Electrochemical and Metallurgical Industry and Iron and Steel Magazine.

Vol. X — New York, September, 1912. — No. 9

PUBLISHED MONTHLY BY THE

Electrochemical Publishing Company

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Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs.)

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Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

New York, September, 1912.

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This month, besides the regular September number, an extra issue will be published on September 12, the day before the close of the Eighth International Congress of Applied Chemistry. It will contain a complete report of the Congress proceedings up to the evening of September 11. It will be distributed at the Congress and mailed to all regular subscribers.

Congress Eve.

Now that the Eighth International Congress of Applied Chemistry is about to convene, the individual responsibilities and individual opportunities of every American chemist loom large. For the first time in the series of these Congresses the United States is to take the pleasant part of the hostess. The organizing committees have finished their work and if most careful and systematic organization can assure success, a great success is assured for the Congress as a whole. The duties of the individual now become of decisive moment.

The object of the Congress is twofold—the promotion of the discussion of professional questions and problems and social intercourse. The national chemical societies of the different countries have done much through their meetings and publications to break down the secretiveness which modern chemistry inherited from medieval alchemy. An international congress must be able to accomplish a great deal more. Its members are enabled directly to put themselves in touch with the chemical knowledge of all the rest of the world, to derive inspiration from meeting the leaders of chemical thought from many countries and to benefit by their free and generous criticism.

Twenty-four volumes of papers printed in advance, one for each section of the Congress, will be available when the Congress meets. For the first time in the history of the Congresses a committee on papers and publications has been given an opportunity to rule with an iron hand. None but papers passed by this committee will be on the program. Their number is some 700. The result is a finished program. When the sectional meetings start they will be able to proceed in medias res. The fact that many papers are printed in advance, and the further fact that the time for presentation of the papers is limited, should insure good and extended discussions. And it is, after all, the discussions of the papers, not their presentation, which must be of prime importance.

However important the serious professional discussions, the social functions of the Congress will be of equal moment. The presence of so many visitors from abroad will afford an opportunity for cultivating that close personal international intercourse upon which all mutual action for the common good of mankind must be based.

A true American welcome awaits our visitors from abroad. Nothing will be left undone to promote their comfort and happinees and to make them quickly and wholly feel at home

in America. We hope that they will enjoy their stay in our country, that they will improve their opportunities of getting a personal insight into our civilization and the spirit of our people, and that in their visits to American chemical works they may perceive the American individuality.

To the hearty words of welcome by Dr. Baekeland, Dr. Doremus, and Dr. Maynard, printed elsewhere in this issue, we need add nothing. What Europe has done for American chemistry is history. The welcome that greets our European friends is but an echo of the welcome that Europe has extended to so many chemists in years past. Love begetteth love.

The Cosmopolitan Quality of Metallurgical Engineering.

The practice of the art of metallurgy is world-wide, and its rapid progress is due to the achievements of many men in many places. Metallurgists have become a cosmopolitan lot, at least through name and reputation, if not by actual travel and residence. A moment's reflection will afford striking instances of the extent to which practice has been modified the world over by the inventions of men once obscure, but later known to the whole fraternity. In some cases we have witnessed a veritable triumphal march of a process or machine from the place of its origin to every country on the globe where it was applicable.

Take stock, for example, of advanced cyanide practice, and its method of application in almost any modern mill. We find in use a chemical principle discovered and developed in Scotland; air-lift agitators invented in New Zealand; tube-mills adapted from the cement industry and first extensively used in gold metallurgy in western Australia; vacuum filters, of one sort or another, the pioneer type of which originated in Utah; slime thickeners and zinc-dust precipitation apparatus, also developed in the United States, and many accessories adopted from world-wide practice. Further argument is not required to show that exponents of good metallurgy have been free from provincial prejudice in constructing plans and executing designs, and have shown themselves ready to adopt ideas from a foreign land.

Other instances of the world-wide adoption of locally invented machines and processes could be multiplied. There are well known examples, also, showing a keenness on the part of metallurgists to adopt principles from other industries. The metallurgy of zinc as originally devised by German and Belgian engineers, is standard practice in the United States and other spelter producing countries; and despite the efforts constantly being made to devise some new and more efficient process, it is likely to lead the way for a few more years to come. This process combines adaptions from other important industries. The manufacture of retorts is a branch of the potter's art; the distillation process bears an analogy to the distillation of other gases, and the calcining of zinc carbonate ore is similar in chemical and mechanical aspects to the burning of lime, and has been carried on in the same manner. Latterly, the manufacture of sulphuric acid has become an important branch of zinc metallurgy, thus reaching into the domain of the chemical engineer. Among machines which have found a wide use in ore-reduction, may be cited German ball-mills in Australia, California stamps on the Rand, and Colorado-made concentrating tables in every country where the concentration of ore is an important industry.

Obviously, such a widespread use of machines, and uniformity of processes, could not have been accomplished by personal effort or without some medium for the rapid transmission of ideas. In this respect, numerous societies, congresses and technical journals have played their important part in promoting the cosmopolitan character of metallurgists and their art. Engineers have contributed freely of their knowledge and experience, often traveling great distances to present personally their ideas. The printed record of their work is distributed all over the world, for every prominent metallurgical society, wherever situated, finds members in foreign countries, eager to learn what their fellow-workers are doing elsewhere. This mutual exchange of knowledge and experience has been the most potent factor in our progress.

In the United States we are on the eve of a convention which exemplifies in the highest degree the cosmopolitan spirit of which we have been speaking. The International Congress of Applied Chemistry meets in this country for the first time. Berlin, Rome, and London have been the scenes of former meetings. Chemists from every country will be gathered in New York in September, for mutual profit and pleasure, and the result should be still further to cement fraternal ties, and wipe out international lines as far as science is concerned.

A Note on Modern Mill Construction.

The use of concrete and structural steel has revolutionized the style and method of building large mills for ore treatment. Advantages have appeared in convenience, cleanliness and beauty. Machines have been more appropriately placed in relation to each other; they are usually accessible for repairs and observation of the work they are doing; ore pulps and water are confined in iron pipes and concrete launders, and there is a welcome absence of the sloppy conditions which formerly characterized many mills. And finally, all of the equipment is housed in a large, airy, well-lighted and comfortable building, in which the attendants work under agreeable conditions, and the casual visitor finds it possible to view operations without being arrayed in overalls and rubber boots.

But with all these features, desirable as they are, the use of concrete and steel may be carried to an extreme in mill construction. The economic limit is set by the fact that the present is an age of rapid progress and radical change in ore treatment, and the mill which is built along such rigid lines that it cannot readily be adapted to improvement, will be handicapped by its inflexibility. The cost of altering or removing concrete and steel structures is not small, and this very fact may necessitate a continuance of operations under conditions which are known to be deficient and not in accord with the best practice.

We do not recall an important mill which has not undergone alterations more or less extensive, involving either a rearrangement of the machinery first used or a complete substitution of different machines to effect better results. The point to be observed is that progress is rapid and change is inevitable, and construction should proceed with that in view. Here is no argument for cheap construction, but a caution against designing and building a mill, and arranging the machinery and its foundations, as though the last word had been spoken in the particular process employed. To-morrow may bring to light an improvement which ought to be adopted. It becomes neces-

sary then to investigate the possibility of adopting that improvement, balancing the extra profit to be gained against the cost of the change. It may be found that the very excellence of the original construction has introduced an obstacle which cannot readily be overcome without excessive expense, which otherwise might have been avoided. There is an economic limit beyond which refinement and permanency of construction should not be carried, keeping in mind the strong probability that alterations will be required by future progress.

The Iron Industry and the United States

From the commencement of the manufacture of "sowe iron" at Lynn, Mass., in 1645, America has certainly made much progress. It was no handicap to America that in many other countries the manufacture of iron was established many centuries earlier, for the whole alignment of the industry has been recast so often that experience has furnished little aid. It has, indeed, been an advantage to the American industry that its large increase in capacity has been in such recent times, for this has permitted the adoption of the most recent ideas in the new construction. Unfortunately there are no statistics to show when the United States passed in tonnage the countries which had earlier established their iron industries. The earliest statistics of the production of pig iron which we have at hand show the United States as holding second place in the family of nations, and in 1890 first place was assumed. It is interesting to observe the pace at which pig iron production was then increasing in the United States. In 1890 this country made 9,202,703 gross tons of pig iron, to England's 7,904,214 tons, and yet that was the first year in which the United States made more iron than England. What is remarkable is that the maximum output of the United Kingdom had occurred eight years earlier, with 8,586,680 tons in 1882, a year in which the United States produced only 4,623,323 tons. Germany in 1890 produced only 4,658,450 metric tons of pig iron. In the present year the United States will make about 29,000,000 tons of pig iron to Germany's 17,000,000 tons and Great Britain's 10,000,000 tons. The production of the United States will thus exceed the combined output of its two nearest rivals, and will indeed constitute more than 40 per cent. of the world's output, which will be in the neighborhood of 70,000,000 tons.

It is not a detached circumstance in the rationale of development of the American iron and steel industry that the tonnage has thus enormously increased. There is an intimate relation between this rapid increase in the tonnage and the manner in which the commercial material has been made. We do not assume that the great increase in tonnage has been due primarily to the activity of the producers, but assume rather that it has been due to the ability of the country to consume. Backed by the necessary raw materials, the producers have simply met the demand. In meeting the rapidly increasing requirements they have not had time to develop any great metallurgical processes, but have rather adopted them ready made from the older countries. What they have done is to practice everything on the largest scale. When they learned how to build blast furnaces, they built them larger than their teachers, and so through all the processes they have adopted, winding up in recent months with the largest electric steel refining units in the world.

We would not slight the part which the possession of magnificent raw materials has played in permitting this remarkably rapid development of the American iron industry. Connellsville coke, of remarkable purity and excellent physical structure, was a necessity in the years when there were no chemists to tell the manufacturers what could be used under this and that set of conditions, and Lake Superior ore, pure, cheaply mined and abundant, was a necessity to the industry which has doubled its tonnage production every decade since that remarkable group of ore deposits was discovered a little more than half a century ago.

In the parallel development of iron mining and steel making there has been what appears to us, however, as a curious piece of luck. In the early days of rapid railroad building the universal demand was for Bessemer steel rails. Given the ore, they were cheaply made, and were incomparably harder and more durable than the iron rails which preceded them, and the United States found itself, in the Lake Superior region, fortified with what seemed to be an unlimited supply of pure Bessemer ores. As time passed, engineers began to express a preference, in many cases, for open-hearth over Bessemer steel and—here the curious coincidence—it began to be discovered that there was not an unlimited supply of Bessemer ores in the Lake Superior region, but that there was a much larger quantity of non-Bessemer ores, above the phosphorus limit for the acid Bessemer process and quite suitable for the basic open-hearth process, though in no case have any Lake Superior ores been found of sufficiently high phosphorus for the practice of the basic Bessemer process so much used abroad. The raw material at the one end and the critical engineer at the other both dictated a change. The engineer at first looked at the basic open-hearth steel askance when the steel maker first cheerfully proffered it to him as a substitute, and had the steel maker wavered the engineer might have triumphed. He could not waver, for though he could have made acid open-hearth steel for a time, eventually the scarcity of ore would have curtailed the growth of the industry. He made good basic open-hearth steel and the engineer accepted it. Thus we find that the maximum production of Bessemer steel occurred six years ago, in 1906, and while this year's production of steel promises to be fully one-third greater than that of 1906, the production of Bessemer steel will not be more than two-thirds as large. The rough sketch of the contest of the processes may be completed by observing that the output of acid open-hearth steel is practically no larger than it was a decade ago, while the output of basic open-hearth steel is double what it was in 1906, quadruple what it was in 1903 and twenty times what it was in 1897, only 15 years ago.

Since the first inception of steel making in the United States the industry has seen alternate periods of capacity exceeding demand, and of demand exceeding capacity. After the rush of 1907 it was thought that for a period of years, perhaps half a dozen, capacity would prove in excess of demand and with reduced prices in the domestic market foreign markets were sought with renewed vigor, the result being that while for several years exports had averaged but slightly more than a million tons a year, in the past few months they have averaged a rate of more than 3,000,000 tons annually, and the United States is beginning to take its place with England and Germany as an important exporter of iron and steel products.

Non-Ferrous Metal Market.

The August market has been generally dull and without feature. In some cases lower prices have prevailed, while in others the prices have been maintained in anticipation of future business. Consumers seem to be well supplied, both at home and abroad, and sales are made for immediate requirements only.

Copper.—The market has been unusually dull, but prices have been maintained by the leading agencies. Lake copper has been in nominal demand only, and its price has been approached closely by electrolytic. The latest reports are: Lake, 17⅛ to 17¾ cents, and electrolytic, 17.45 to 17.50.

Tin.—The foreign market declined after the Banka sale, and the domestic market has been without feature. Prices for August delivery averaged about .45⅛ cents.

Lead.—Prices have fallen since our last report. On Aug. 5 the American Smelting & Refining Company reduced its price to 4.50 cents, and a better demand has resulted. The closing quotations are: 4.50 cents, New York, and 4.35 to 4.37½ St. Louis.

Spelter.—The premium on spot metal has disappeared and most of the transactions are for future delivery. Some business has been done for the fourth quarter of the year. Prices are slightly lower, averaging 6.90 to 7 cents, New York, and 6.75 to 6.85 cents, St. Louis.

Other Metals.—A more active market is noted in aluminium, antimony and quicksilver. Fair sales of aluminium have been made at 24¼ to 24½ cents, New York, and prices are firm. Business in antimony continues active, with prices ranging from 7.50 to 8.50 cents for various grades. A premium has been asked for spot metal of Cookson's brand. In quicksilver, the New York market quotes flasks of 75 lb. at $42.50, with slightly higher prices for small lots. At San Francisco the quotation is $42 for domestic and $39.50 for export business.

The Iron and Steel Market.

The finished steel market has been passing through one of the most remarkable periods in its history, for in July and August, which normally are very dull months, prices have been steadily advancing, specifications have been very heavy and the attitude of sellers has been increasingly optimistic. Producers of steel express the opinion that the course of the market has been absolutely without a parallel. They deny any similarity with the movement in 1909, when as may readily be recalled the market improved rapidly and steadily from June until almost the close of the year, prices advancing by an average of about $5 a ton. It is possible that their refusal to admit that there is any similarity is due to their recollection that the 1909 improvement was short lived, being followed by a year of sagging prices and decreasing production, so that if present conditions are similar to those which obtained in 1909 the outlook is distinctly unfavorable, rather than extremely favorable, as is generally claimed. While the statement is freely made that conditions are not similar to those obtaining in the summer and fall of 1909, it is not possible to back up the statement with concrete facts, for in the ultimate analysis the question is whether buyers are buying speculatively, whether any large part of the increased demand is due to buyers replenishing stocks, anticipating requirements by filling specifications early, depending on the crowded condition of mills to delay delivery, and actually accumulating stocks for speculative purposes. In 1909 it was denied that such conditions existed, yet the experience of 1910 showed that they had existed. Time will tell, and meanwhile it may be observed that neither buyers nor sellers are evincing any disposition to be conservative. The former are advancing prices and the latter are buying freely.

Throughout the industry stoppages for repairs in July were as short as possible, and production was but little reduced from this cause. Hot weather also caused a slight curtailment. By August repairs were practically all completed, and weather conditions in the month were unusually good for the season, so that August production showed a material increase, closely approximating, if not actually exceeding, the June rate. There is every prospect that the steel mills will operate at substantially full capacity through the balance of the year. Merchant blast furnace operations, which represented not more than 60 per cent of capacity, have increased, and further increase is promised in the next month or two.

Bars, plates and shapes were advanced at the beginning of August by $1 a ton, and about August 20 another increase of $1 a ton became effective upon plates and shapes. The exact *modus operandi* of these advances is not fully understood. The public is frequently assured that there is no semblance of a price agreement in the finished steel trade, whereas the suddenness of the advances, which occur almost overnight, does not suggest entirely open market conditions. Only in a market of extreme strength could advances become universal in such short periods.

A composite of the leading finished steel products, including bars, plates, shapes, tubular goods, wire products, sheets and tin plates, shows that the low point in the present year (a point slightly higher than the November low point of last year) obtained in the latter part of February and the early part of March, while from then to the middle of June there was an average advance of $2 a ton and from the middle of June to the close of August there was an advance averaging slightly more than $2 a ton, so that prices advanced more rapidly in what is usually a dull period than they did in what is usually an active period.

Pig Iron.

Pig iron has shown a more sharply advancing tendency than at any previous time in this upward movement, which began about the first of the year. The recent advances are attributable not so much to there being a large tonnage bought as to demand closely approximating, if any actually exceeding, the current rate of output. At such a critical stage a small variation in either demand or production makes a very large change in the course of the market. For many months demand slowly increased while stocks decreased and production remained almost stationary. It is possible that the current melt of merchant pig iron is now in excess of the current make. As a rule idle furnaces do not readily get into blast, as prices are still low, and the idle furnaces are largely those which were forced out of the running long ago, before prices had declined to the extreme low point. The principal pig iron advances since late in July have been: Southern and Chicago foundry iron, 50 cents; Eastern foundry, 25 cents; Eastern basic, 50 cents; valley foundry and basic, 50 cents; valley Bessemer, 25 cents. We now quote: Southern foundry, Birmingham, $12; foundry iron, f. o. b. Chicago furnaces, $15.50; No. 2X, delivered Philadelphia, $15.75; basic, delivered eastern Pennsylvania, $16; foundry, basic and malleable, f. o. b. valley furnaces, $14; Bessemer, valley, $14.75.

Steel.

Unfinished steel has grown extremely scarce in the different markets. Several months ago the Chicago district mills withdrew as regular sellers of billets. Later most of the Pittsburgh mills withdrew and then steel became scarce at Youngstown and in the East, leading to a condition in August in which there was little steel obtainable in the Central West, except occasionally from brokers and small mills, the Eastern mills remaining as sellers, but at advanced prices. The market stands approximately as follows, f. o. b. maker's mill, Pittsburgh or Chicago: Bessemer billets, $22.50; Bessemer sheet bars, $23; open-hearth billets, $23; open-hearth sheet bars, $23.75 to $24; rods, $25 to $26. Large consumers had large contracts for the current quarter, but their requirements have been so heavy that they have specified the maximum tonnages permitted in the contracts, and have endeavored to buy additional tonnages, but as prices have been much above the contract level the purchases have been relatively light.

Finished Steel.

A summary of advances in this movement in steel tubular goods is as follows, each advance being one point or about $2 a ton: Boiler tubes, May 21 and August 1; Merchant pipe, June 1 as to 6 in. and under, July 1 as to sizes above 6 in.; July 25 as to all sizes; Oil country goods, June 1 as to 6 in. and under, July 1 as to sizes over 6 in.; August 1 as to all sizes. The total advance in all steel tubular goods in this movement has thus been about $4 a ton.

Current prices, f. o. b. Pittsburgh, unless otherwise stated.

Rails, standard sections, 1.25 cents for Bessemer, 1.34 cents for open-hearth, f. o. b. mill, except Colorado.

Light rails, 16 and 20 lb., 1.24 cents; 25 to 45 lb., 1.19 cents.

Plates, tank quality, ¼ in. and heavier, 1.40 cents.

Shapes, 1.40 cents.

Steel bars, 1.30 to 1.35 cents.

Steel hoops, 1.40 cents.

Iron bars, 1.40 cents, Pittsburgh; 1.35 cents, Philadelphia; 1.40 to 1.45 cents, Chicago.

Sheets, blue annealed, 10 gage, 1.50 cents; black, 28 gage, 2.05 cents; galvanized, 28 gage, 3.15 cents; painted corrugated, 28 gage, 2.20 to 2.25 cents; galvanized corrugated, 28 gage, 3.10 to 3.20 cents.

Tin plates, $3.50 for 100-lb. cokes.

Merchant steel pipe, ¾ to 1½ in., 79 per cent off list.

Steel boiler tubes, 3½ to 4½ in., 73 per cent off list.

Standard railroad spikes, 1.65 cents, Pittsburgh; 1.75 cents, Chicago.

Electric Steel Refining at Bethlehem Steel Co.

The Bethlehem Steel Company, of South Bethlehem, Pa., manufacturers of tool steel, armor plate, projectiles, and other lines of high-grade steels, have decided to install the Girod electric furnace which shall enable them to produce a much

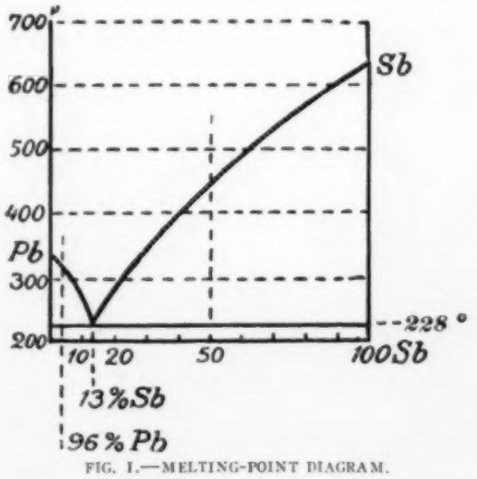


FIG. 1.—MELTING-POINT DIAGRAM.

larger quantity of special steel. The first Girod furnace to be installed by the Bethlehem Steel Company will have a melting capacity of 10 tons per heat.

Among the European users of the Girod furnace is the famous firm of Freidr. Krupp, of Essen, Germany.

The design of the Girod furnace and the progress which it has made in practice, have been the subject of numerous notes and articles in former volumes of this journal, among which should be especially noted the paper by the inventor himself, Mr. Paul Girod, in our vol. VII, p. 259 (1909), the description of the electric steel plant of the Société Anonyme Electrométallurgique Procédés Paul Girod in Ugine Savoy, France, in our vol. VII, p. 9 (1909), and the paper by Mr. Müller on Girod furnace practice in Gutehoffnungshütte, Germany, in our vol. IX, p. 581 (1911).

The Production of Porous Metals*

A Novel Application of Eutectic Alloys for the Production of Storage Battery Plates.

By H. I. HANNOVER.

The eutectic alloys has the lowest melting point of all the alloys that can be made of the same two metals.

Fig. 1 shows a diagram of the conditions of solidifying for all the alloys of *lead* and *antimony*. The abscissas give the composition of the alloys, in percentage of the antimony, and the ordinates the temperatures of solidifying. Thus the ordinate to the left refers to pure lead (0 per cent Sb) with a melting point of 328 deg. C. and the ordinate to the right to 100 per cent antimony with a melting point of 630 deg. C.

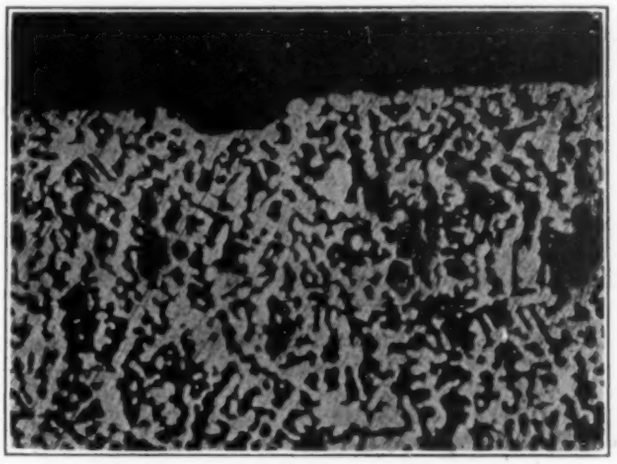


FIG. 2.—POROUS LEAD PLATE.

It will be seen from the diagram that the alloy with 13 per cent antimony and 87 per cent lead has the lowest melting or solidifying temperature of all the alloys 228 deg. C. This is the eutectic alloy. After solidifying it shows up in microscope as alternating leaves of lead and antimony. All other alloys of the two metals may be considered composed of the eutectic alloy and lead, or the eutectic alloy and antimony. If, for instance, an alloy with 50 per cent antimony has been melted and is allowed to cool, lumps of antimony will begin to form, at a temperature of about 450 deg. C. As the temperature goes further down the mass becomes more and more lumpy. When the temperature of 228 deg. C., is reached, all tre antimony has solidified, which does not belong to the eutectic alloy, and at this temperature the eutectic alloy solidifies at once.

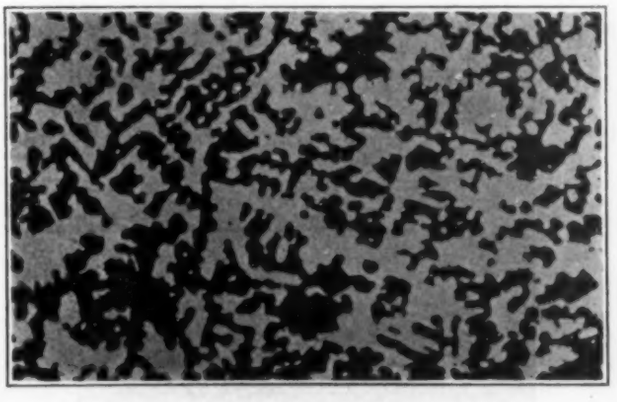


FIG. 3.—POROUS TIN PLATE.

If on the other hand an alloy consisting of 4 per cent an-

*Translated in abstract from *Ingenioren*, June 15, 1912.

timony and 96 per cent of lead is completely melted and is cooled down, then at about 315 deg. C. crystals of lead begin to form, and as the temperature goes further down, more and more crystals are formed, until a coherent body of lead crystals is produced. However, in this are still millions of fine pores

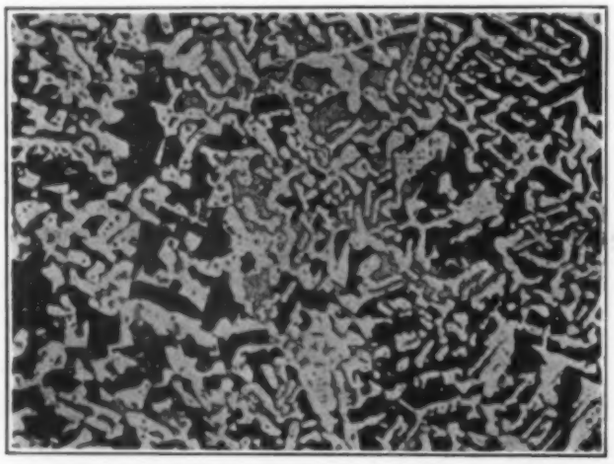


FIG. 4.—POROUS ANTIMONY PLATE.

filled with the melted eutectic alloy. As soon as the temperature has gone down to 228 deg. C., the content of the pores, the eutectic alloy, solidifies at once. This contains all of the four per cent of antimony, which must be connected with $4 \times 87/13 = 27$ per cent lead. The previously solidified lead was therefore $100 - (4 + 27) = 69$ per cent of the whole amount of the alloy.

Inversely, if a solidified plate is heated, the veins of the eutectic alloy will melt first. This is the basic principle of my new process for the production of porous metals.

After trying different methods for removing the melted eutectic alloy from the lead (or antimony) body, I finally adopted a centrifugal separator.

When I first started these experiments, it was from purely scientific interest. Not until I had the method fairly well in hand, it occurred to me that there might be a practical field for such porous plates as material for electric storage batteries.

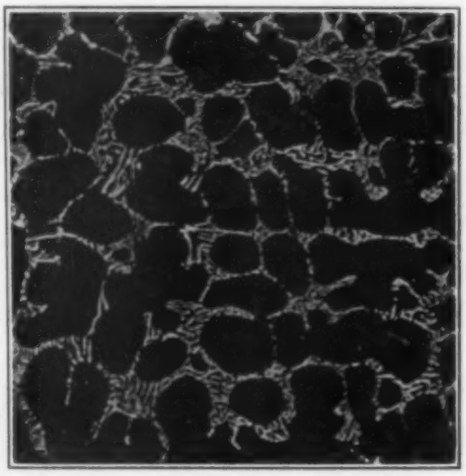


FIG. 5.—94-LEAD, 6-ANTIMONY ALLOY.

I made some experiments with bismuth and cadmium, but finding that they were too high in price to be considered for any practical purpose, I have since confined myself to the lead-antimony alloys. With a percentage of lead of 96 per cent, as described above, almost all the antimony is driven out with the eutectic alloy; but a very thin film of this remains on the walls of the pores, and after solidifying it strengthens the lead plate, without decreasing noticeably its efficiency as accumulator plate. According to tests made by Professor Rung, accumulators of such porous lead have 4 to 4½ times as high a capacity as an ordinary accumulator of the same weight.

Professor Henry LeChatelier in Paris, has taken much interest in the results obtained so far, and has made the invention the subject of a lecture before the Academie des Sciences, and by his courtesy the accompanying micro-photographs of

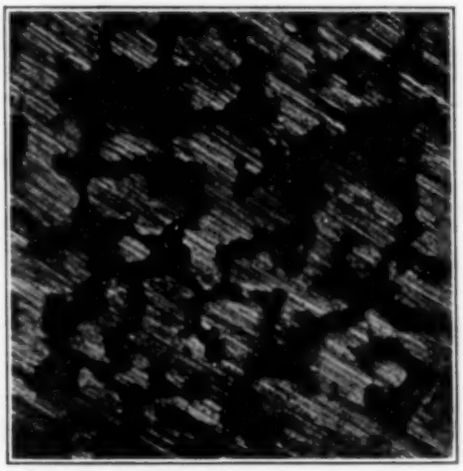


FIG. 6.—SAME PLATE AS FIG. 5 AFTER REMOVAL OF EUTECTIC ALLOY.

cuts through some of my porous plates have been made. Fig. 2 shows a cut through a porous lead plate, Fig. 3, through a porous tin plate, and Fig. 4 through a porous antimony plate. From the latter the eutectic alloy had not been driven out properly; what had been left in the pores shows up gray in the cut. The magnification for all of these photographs is 40 diameters.

Fig. 5 shows a cut through an alloy of 94 per cent lead and 6 per cent antimony, as it will solidify if not interefered with. Fig. 6 shows the same after heating, melting of the eutectic alloy, and removal of the same. The last photograph does not show up clearly on account of a poor microtom-knife having been used for cutting through the plate. For the last two photographs the magnification was 15 diameters.

The future will show if this invention is to be of any practical value. But I do not think I am claiming too much in claiming for it some scientific interest. For thousands of years man has known massive metals, but only a few special cases of porous metals, in small amounts, as for instance, spongy platinum, and now at once we are enabled to produce a number of metals as porous metals and in large quantities. Furthermore, this is an invention which a man with purely practical education would not have been able to make, as he is without knowledge of the microscopical structure of the alloys.

CORRESPONDENCE.

Drying Air for Blast Furnaces.

To the Editor of Metallurgical and Chemical Engineering.

Sir: The paper by Mr. Bruce Walter on his new dry blast process, presented before the Engineers' Society of Western Pennsylvania and published in your August issue, p. 471, is certainly of considerable interest. But I cannot help but think that the discussion would have been more complete if someone had taken the pains to refer to the admirable paper by Mr. J. E. Johnson, Jr., read before the Iron and Steel Institute in 1906, and abstracted in your volume IV, p. 349 (September, 1906).

In this paper Mr. Johnson showed the absolute necessity for

two-stage refrigeration, both from the point of view of low first cost and operating efficiency, and the necessity, from the same points of view, of doing away with the indirect system of brine circulation. He also gave methods of calculating power requirements which are almost childishly simple as compared with those of either Mr. Walter or Mr. Carrier, although the latter's contribution to the discussion is quite remarkable.

Mr. Johnson's paper of six years ago seems to have been a little ahead of the time. But even now Mr. Johnson's paper deserves the most careful attention of everyone interested in the subject, since in that paper the fundamental principles which must guide all future inventors are clearly outlined.

East Orange, N. J. EDWARD BERT.

Some Observations on the Amount of Combined Carbon in Pig Iron.

To the Editor of Metallurgical and Chemical Engineering.

Sir: In the August issue of your magazine were published two very interesting photomicrographs of electric pig iron, with a discussion of its properties. The unusual features are the absence of sulphur, and manganese, the low percentage of phosphorus, and the total absence of combined carbon.

The latter fact directs our attention to the omission of data concerning the conditions under which the iron was cooled, particularly from solidification, to the pearlite transformation point. Though this omission is quite common in the literature of the subject, the matter is none the less important for the correct application of the micro-structure to the physical properties of castings made from the iron.

It is well known that current furnace practice varies widely on the rate of cooling hot metal from a liquid condition to ordinary temperatures. The extreme example is the pig machine, which does the job in a very few minutes. Probably the average practice in sand cast furnaces is to allow the iron to cool in the sand for an hour or less, and then chill with water from a

FIG. 1.—MICROPHOTOGRAPH OF ORIGINAL PIG. 10 DIAMETERS.

more or less bright red heat in about 40 minutes. At the other extreme might be cited a furnace that runs cinder over the pig beds after the iron is run, and allows the latter to cool by radiation entirely, taking at least three times the average.

That a change in the rate of cooling will exercise an important influence on the amount of carbon remaining combined with the iron, is only another way of stating the well-known fact that the reactions $\left.\begin{matrix}\text{cementite}\\ \text{austenite}\end{matrix}\right\} \longleftrightarrow \left\{\begin{matrix}\text{austenite}\\ \text{pearlite}\end{matrix}\right.$ will show a considerable lag if the rate of cooling is accelerated.

This is well illustrated by Figs. 1 and 2. Fig. 1 is a section cut from the center of a sand cast pig that had been cooled in the regular manner practiced at that furnace. The pig was then melted in an ordinary pot furnace in a plumbago crucible, with the usual precautions to prevent oxidation. About 75 lbs. was used, and from the melt, a short pig was poured in fairly dry cast house sand. This pig was allowed to cool by radiation without being removed from the sand. At the end of 2½ hours, the pig could be handled with the hands, and was therefore well below the transformation range. The cooling of this second

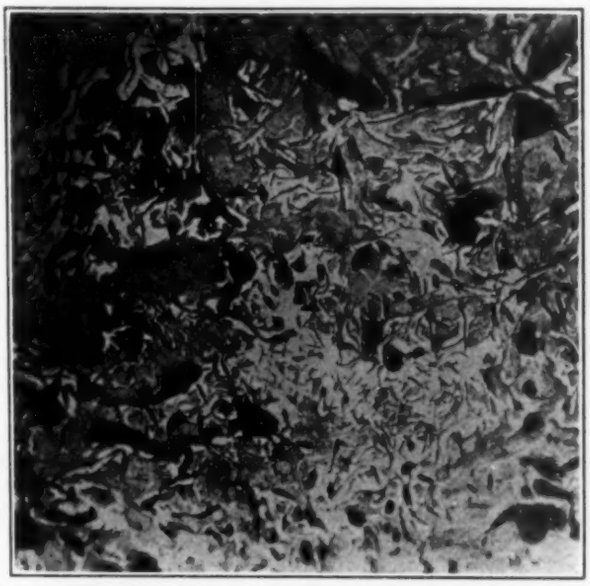


FIG. 2.—MICROPHOTOGRAPH OF NO. 1 AFTER REMELTING AND COOLING NATURALLY. 10 DIAMETERS.

pig, then, could not have been more than 1 hr. slower than that of the first pig at the furnace. Fig. 2 is a section from the center of the remelt. Both samples were etched with 5 per cent picric acid solution in alcohol, and photographed at 70 diameters.

Fig. 1 shows nearly eutectoid pearlite, with a small amount of excess ferrite, and some phosphide eutectic. Fig. 2 however, shows a marked difference, in that there is a large amount of excess ferrite, and a correspondingly smaller amount of pearlite. The phosphide eutectic is present in about the same proportion as in the former sample. The following analysis, made by another chemist, will show that the change in combined carbon cannot be attributed to a different proportion of metalloids in the second sample.

	Fig. 1.		Fig. 2.
Si	1.20	Si	1.10
P	.256	P	.259
Mn	.40	Mn	.38
S	.035	S	.038
T.C.	4.00	T.C.	3.91
Graphite	3.26	Graphite	3.35
C.C.	.74	C.C.	.56

It will be noted that only 0.10 per cent of the silicon has been oxidized and only 0.09 per cent of carbon. The fact that phosphide eutectic appears in both samples would tend to eliminate phosphorus as a factor. Therefore, it seems safe to conclude that the slower rate of cooling in the remelt has resulted in materially lowering the combined carbon. This conclusion has been confirmed on samples containing widely varying proportions of the metalloids.

It is believed that a further study of the conditions affecting the proportion of combined carbon to graphite and to total carbon will prove extremely useful in solving some of the practical problems in the complex metallurgy of cast iron. In view

of the fact that the microscope is just beginning to assume practical importance in this field, it would seem that we could not be too careful to study out and record all the conditions that may have a bearing.

Pittsburgh, Pa. C. T. Dawkins.

* * *

To the Editor of Metallurgical and Chemical Engineering.

Sir: Replying to Mr. Dawkin's friendly criticism of the article by Mr. F. C. Langenberg and myself upon a "Microscopic Study of California Electric Furnace Pig Iron," the writer would say that he is fully aware of the influence which the rate of cooling has upon the structure of iron and upon its relative graphitic and combined carbon content. However, as it was impossible to obtain exact data as to the manner in which the pig was cooled from which the specimen was taken, and which was used in making the microphotographs, we made no mention of this point in our article, but we expect in a future study of this subject to fully take this factor into account.

Pittsburgh, Pa. D. A. Lyon.

The Present Situation in the American Institute of Mining Engineers.

To the Editor of Metallurgical and Chemical Engineering.

Sir: The American Institute of Mining Engineers has labored for some years under three separate difficulties.

1. Ill-defined division of responsibility, in the dual control of its activities, between the Board of Directors and the Council.

2. The independence of the Secretary of the Council, because of his election by the Institute at large, of the body he is supposed to serve; an illogical situation.

3. The possibility afforded, by the present form of Constitution and By-Laws of placing the management of the entire affairs of the Institute in the hands of a single individual.

The directors are made solely responsible for the funds and property of the Institute by the incorporation laws of the State of New York. The Constitution places the management of all its professional and social affairs in the hands of the Council who may, and who have in the past, in arranging them incurred indebtedness for which the directors are responsible; but in which they have frequently had no voice. This should be changed so that no expenditures can be incurred except on previous appropriation by the Board of Directors.

The secretary has been the executive officer and has the power, under the Constitution, of incurring debts in the name of the Institute, auditing the bills and paying them without consulting either of the governing bodies.

As shown in the report of the committee of five, the Institute has for some years been short of funds. Its annual income has not sufficed to meet all of its financial obligations.

The main reasons for this condition are:

1. The expense incurred by the interest in the United Engineering Society Building.

2. High salaries and inefficiency in the office work.

3. The large proportion of life members whose commutation of dues has been spent for current expenses as fast as received, while the obligations of the Institute to them are continuous.

4. The large number of delinquent members carried on the books and supplied with publications.

Together the life members and delinquents are about one-fourth of the total, so that the entire expenses are paid by about three-fourths of the membership.

It is generally admitted the Constitution should be amended, and in so doing we believe the difficulties mentioned above should be borne in mind and every effort made to remove them.

It is hardly possible to do away with the dual control of directors and council without putting the control entirely in the hands of the New York members, which they do not desire, and which would not be for the good of the Institute. The incorporation laws place the responsibility so entirely in the hands of the directors that in order to have meetings most of them must be residents of New York or vicinity, or the power be delegated to an executive committee of such residents which amounts to the same thing.

For this reason the dual control will have to be continued.

The undue influence of the secretary of the council should, and can be, obviated by abolishing his election by the membership at the annual meeting and by letting the council elect their own secretary subject to their own pleasure. A one-man management can be prevented by changes in the Constitution and by-laws precluding the occupancy of certain offices by the same individual.

Two policies have been in mind for the future management of the Institute. One is a continuance of the present predominating influence on the part of a single individual; the other a practical divorce of the business management and the professional activities so that they will not come in contact except at a single point.

In the past the Institute has had an especially versatile and energetic secretary; but even in this case the number of those who have not agreed with his policy has increased until they now probably constitute a considerable majority of the Institute. Even if it were desired to continue what is practically a one-man management, and if an individual combining all of the necessary qualifications could be found it is doubtful whether the Institute, with its present obligations and comparatively small membership could afford to pay sufficient to obtain him.

We believe it would be better, at least for the moment, to have a business manager selected by and responsible to the directors and have the editorial work, so far at least as the selection of material goes, performed by a committee on papers and publications, as is done by most similar societies who attempt to manage their affairs economically; the papers so selected to be turned over to an editor and the business manager, who would attend to the details of publication and distribution.

The expenses of the United Engineering Society Building have been incurred and must be provided for. It is therefore either necessary to increase the income of the Institute, decrease its expenditures, or both.

The former result can be obtained by making the Institute of greater value to its members which would probably result in increasing the membership, the latter result by more efficient management at the head office and by eliminating various subsidiary activities not strictly a part of the Institute's business.

We believe that the membership can be largely increased, as other societies of similar aims and scope have grown largely in the past few years, while the Institute has stood still. An increase in the membership beyond the present number will increase the income much more rapidly than the expense, so that a comparatively small number of additional members would place the Institute in an easy financial position.

We believe this to be a better and surer way of providing the needed funds than to increase the dues, which would undoubtedly cause enough resignations to make the financial result uncertain.

When a large proportion of the members are dissatisfied and are asking themselves whether they are getting a proper return for their money it is a bad time to ask them to pay more unless they can be clearly shown that they are to receive an adequate return.

We believe that by lopping off some unnecessary expenditures, by still closer supervision on the part of the Board of Directors considerable economies can be effected without in any way curtailing the work which the Institute was called into existence to do.

New York City. Geo. C. Stone.
C. R. Corning.

The Eve of the Eighth International Congress of Applied Chemistry

An American Welcome

Reminiscences of the Congresses of Berlin and London.

To the Editor of Metallurgical and Chemical Engineering.

Sir:—When I think of it I feel astonished that almost ten years have elapsed since that sunny morning when we all gathered before that imposing Reichstags Gebäude in Berlin. From our little group of about thirty American chemists arose many a "Hello old chap" interchanged with a "Wie geht's" or some other hearty exclamations, renewing friendships made long ago in German universities, until after a while all these happy exclamations catalyzed the gathering to a spreading fermentation of friendly feeling and rapidly increasing cheerfulness.

And then followed busy days in all the different sections, much engaged in their own specialties, from where we emerged now and then to meet all together at the general functions, lectures, and receptions without end. The most memorable event was undoubtedly the general meeting in the Reichstags Gebäude. That imposing building of the German Parliament by itself lent much dignity to the meeting at which were present some representatives of the imperial family; the whole session assumed the impressiveness of a function of state.

Well do I remember also how some of our Americans who stayed all at the Hotel de Rome hesitated to leave the hotel at nine o'clock in the morning, dressed up in regular evening suit to conform to the officially prescribed continental etiquette. Some of the more formal of our New Yorkers insisted that we had misread the German directions and that "frock coat" was intended. It was only after they had seen some congressionists walking happily and unconcernedly in the full sunlight of the street, with white starched shirt bosoms, white neckties and swallowtails, that they, too, pitched up their courage to don their evening suits.

The "white necktie" appeared to be a very essential thing then and the governmental usher at the door was very particular on this subject. I saw him refuse admission to a friend of mine, a well known Russian chemist, because he had a dark necktie. But this serious difficulty was soon adjusted by my resourceful Russian friend, who tore off his black necktie, and then walked in without further trouble and without a necktie, screening the front button of his collar under his beard which looked like a bunch of oakum.

Our German hosts had spared no opportunity to prepare us an elaborate program of entertainments of every kind, and on every occasion blossomed their national virtue, "Gemütlichkeit," which shall ever linger in the memory of all of us who were there. While I am scribbling this there still rings in my ears that hearty, wholesouled laugh of our Dr. William McMurtrie, at that time so brimful of interest for all that happened, and so keenly alive to all the latest chemical work which was then going on. Alas! dear Mac, we shall miss you much this time when your cruel sick-bed will keep you away from so many of your friends of all nations.

To my regret I was unable to be present at the Rome Congress, which from all reports was a worthy successor of that of Berlin; but I had the good fortune to participate at the London Congress. Never shall I forget those days of the spring of 1909 when our little band of American chemists, some with our wives, left on the steamer Kroonland, where we soon acquired the happy feeling that everything on the ship, inclusive captain, stewards, brass band, pantry and refreshments, belonged to the American Chemical Society. Brother Wiley made wit and humor so contagious that the Captain soon relinquished his presiding seat at the table to better listen to the never-ending repartee and declamation of the apostle of pure food and good stories.

The inaugural meeting at the Royal Albert Hall, presided by the then Prince of Wales, now the King of England, and his wife, made a fitting counterpart of the similar function of the Berlin Congress. Sir William Ramsay as president of the Congress had arranged a program at least as imposing as that of any of the predecessors; all this was blended with the gentle, charming English hospitality displayed on so many occasions.

The official reception at the Foreign Office was a very brilliant affair. One of the most distinguished and elaborate social functions was the feast offered by the American Ambassador. This was preceded by a dinner party, where the six or seven American Government delegates were invited with their wives. After the dinner was over, we were led to the immense drawing room of the embassy, where a reception was held and which soon filled with the elite of chemical and diplomatic representatives of all countries. Dorchester House with all its sumptuous halls added to the impressively generous scale on which this reception was conducted, yet with it all there reigned a note of dignified cordiality which largely contributed to the success of the evening.

And now the time has come when we shall be able to try to reciprocate all the hospitality, all the favors which we have received abroad. I take it for granted that none of us who has been to any of the past congresses will need to be urged to do his best to keep up the reputation of American hospitality.

Men like Dr. Nichols, Dr. Hesse, have now spent more than two years of their best energies to make this Congress a success; they have been warmly seconded in their efforts by the executive committee and by many others who have often neglected their daily duties, have submitted themselves more than once to great inconvenience to be present at the numerous preparatory meetings.

But this is not enough, we need the help of all. Let every chemist of the United States, every chemical manufacturer or chemical merchant, any one who is convinced of the growing importance of chemical science, use his best efforts to make this Congress, not only an honor to our Republic, but an opportunity to show gratitude and appreciation for the inspiration and help this country has derived and is receiving daily from the able work that is carried on abroad. Every progress of chemistry involves the direct benefit, not of one nation alone, but of the world at large.

The past work of Lavoisier, Scheele, Humphrey Davy, Liebig, Pasteur and many others who have left us long ago still makes deep imprints on the welfare and the intellectual development of every nation of the earth.

The work of the chemist of today confers in no lesser degree benefits of unrestricted international magnitude. A chemical discovery made today in one part of the world finds its applications everywhere. Nay, more, it quickens the pulsations of the imagination of thousands of chemists of other nations; it induces them to follow any new path just laid bare by a pioneer; it stimulates further and more exhaustive research. This is the main reason why nowadays the development of a new conception proceeds with a rapidity never known heretofore in the intellectual development of our race.

Bear in mind, fellow Americans, this country cannot rival even with the smallest European monarchy in pomp and display of governmental functions. Neither should we have the slightest cause of regret for this; we can abundantly make up for all this if we will endeavor to display our best qualities as private

citizens come together to honor our distinguished foreign guests.

Fellow Americans, up till now your busy occupied life may have left you unaware of the event which is fast approaching. Well, just now, drop all your petty private matters, your business cares for a few days. Don't say you cannot spare the time; a few years more you will be dead and you shall have to spare everlasting eternity. If you have a wife, daughter or sister who is not hopelessly without brains, take them along; it will do them good to observe some of the real work of the world and they will later on take more interest in your own work. Mingle with your fellow chemists of many nations, listen to them, let them be your teachers, measure your own work, your own thoughts by theirs. Do not limit yourself in your hospitality to the sheer display of expensive entertainments—any nobody with more money than you can outdo you in this. But offer your fellow chemists the very best you have in you, something money cannot purchase—a high thinking mind and a cheerful brotherly heart.

And then, after the Congress is over, be thankful to have received this splendid opportunity for renewed inspiration in witnessing the brilliant results of the efforts of others. This is the most powerful way to make the Congress an immense success and to honor our guests.

Leo H. Baekeland.

Yonkers-on-Hudson, N. Y.

* * *

Influence of Paris Congresses.

To the Editor of Metallurgical and Chemical Engineering.

Sir:—You have asked me to pen a welcome to our French confrères. Though using English they will easily interpret the cordiality and sincerity of my greeting.

As our friends approach this city they will surely be delighted at the sight of that idealistic tribute of friendship which their compatriots have erected as an expression not only of amity between the two nations but as symbolical of Liberty. It would be quite appropriate for Bartholdi's masterpiece to salute them as they pass through waters where Fulton made steam navigation real and where now the hydroaeroplane rises bird-like from the surface to circle about the statue and soar over and under the many bridges.

On the reverse of the medal struck in honor of Berthelot's semi-centenary of research is the inscription:

"Pour la Patrie et la Verite."

Let us imagine the goddess of Liberty, her torch aflame, transformed into the goddess of Truth, mirror in hand, and that the first President of the American Chemical Society, John W. Draper, is closing his inaugural address:

"Nature, the mother of us all, has inscribed her unfading, her eternal record on the canopy of the skies, she has put it all around us on the platform of the earth!" * * * To those who in purity of spirit worship in her heaven-pavilioned temple, she offers her guidance to that cloudy shrine in which Truth sits enthroned, "dark with the excess of light?" Thither are repairing, not driven by tyranny, but of their own accord, increasing crowds from all countries of the earth, conscious that whatever their dissensions of opinion may heretofore have been, in her presence they will find intellectual concord and amity."

May the love of Liberty and Truth guide the deliberations of the Eighth International Congress of Applied Chemistry and cement the bonds of the brotherhood of Nations.

While ancestor worship is preeminently an attribute of Orientals hero worship is common to Occidentals. But the heroism of deeds of War is giving place to the heroism of deeds of Peace.

Pasteur was by popular vote of the nation acknowledged as the greatest of Frenchmen. The beneficient results of his researches have been felt throughout the world.

It was appropriate for the members of the Second International Congress, held in Paris, in 1896, to place a commemorative wreath upon his casket, then resting in the great cathedral of Nôtre Dame.

The visits afterwards made to the Pasteur Institute, where patients were seen receiving the treatment for rabies, and to the suburban laboratory where the anti-toxins, especially that of diptheria, were prepared, demonstrated most forcibly that he had created a new era in medicine. Having been able to assist Dr. Valentine Mott to make the first inoculations of rabies in this country, from virus obtained from rabbits brought from Paris, at a time when medical men held aloof and made disparaging comment on the treatment, it is most gratifying to know that it is now not only recognized as the sole and proper treatment for hydrophobia, but is officially endorsed.

Such topics interested Pasteur in his last days, but how wonderfully successful were his researches in fermentation, in silkworm disease, in chicken cholera, and his earliest work on the tartrates, initiating new conceptions in theoretical chemistry.

The Second Congress had for its president the renouned Berthelot. He too was a master in many fields. Synthetical

MARCELIN BERTHELOT.

chemistry; the direct union of hydrogen with carbon to form acetylene; the preparation of compounds representing almost every group in organic chemistry. Researches in thermochemistry typified on the medal by the bomb calorimeter, the simple apparatus now so extensively used to determine the heating value of fuels and to disclose many important truths in general chemistry. Investigations on explosives; on the influence of electricity on the growth of plants; encyclopedist; Senator; Minister of Public Instruction; Perpetual Secretary of the Académie des Sciences; a man whose activities were so broad, so beneficial to the nation that its gratitude found expression in public obsequies and burial, his devoted wife beside him, in the Pantheon.

You have suggested, Mr. Editor, that personal reminiscences be given illustrating the influence of international intercourse in promoting the progress of chemical and metallurgical professions and industries.

It was my very good fortune to meet Henri Moissan during the sessions of the Second Congress. Two of his masterly re-

searches interested me intensely—the isolation of fluorine and his work with the electric furnace incidental to the making of diamonds. What bold investigations! The evidence of the existence of the element fluorine was so conclusive, yet the element so elusive! But Moissan was determined. He says in his monograph on his subject after noticing the charring of the cork closing the arm of the apparatus carrying the positive electrode; "Evidently a gaseous body, possessing active properties had been produced at the positive pole. I thus got, after three years of research, the first important clue in the isolation of fluorine."

The costly platinum apparatus, with its platinum-iridium electrodes, was supplanted later by one with a copper container, and thus simplified led to the production of ozone by the action of fluorine on water vapor.

While this research made him famous among scientists, that on producing diamond gave him a world-wide reputation. That by dissolving carbon in molten iron at high temperature in an electric furnace and then plunging the molten metal into water

By courtesy of Berlin Photographic Co.
PASTEUR.

where under great pressure the carbon crystallized as it segregated on cooling he actually obtained diamond, was to me convincingly shown by the microscopic specimen of the crystals bearing the characteristic markings of natural diamond.

Later in a lecture delivered in New York at the College of Physicians and Surgeons on invitation of the American Chemical Society, the American Institute of Electrical Engineers, the New York Acadamy of Sciences, and the New York College of Pharmacy, he showed this experiment to the delight of scientists and experts who had followed his words in eager interest. His perfect clarity and diction, his direct and forceful logic captivated his auditors. Among my scientific treasures is the major portion of that ingot.

His work on the carbides followed naturally from this investigation at high temperature. To these must be added that on the borides, silicides and other compounds, as well as the making of purer metals and the properties of those metals having high boiling points, the results of which last research he placed before the Congress at Rome.

He made a visit to Edison at his laboratory. The men were in remarkable contrast. Pioneers both, though each with different methods and with different objective points. The one primarily the scientist, the other the utilitarian, yet each over-

HENRI MOISSAN.

lapping their self-selected bounds and each leaving an impress beyond by reason of their digression. Marvelous advances since then. Our foreign friends will perhaps be snapped by the moving camera men; what they say in meeting will certainly be recorded by the phonograph.

A reflex of what was witnessed in Paris was the organization in this country of the Ampère Electrochemical Company for carrying out important experimental work. The development of the alundum industry, the barium process, making of cyanides, and incidentally the making of barium and calcium cyanamides; the production of silicides, which when acted on by water evolve hydrogen; and as an independent investigation the first commercial production of nitric acid from atmospheric nitrogen.

While C. S. Bradley, C. B. Jacobs, and D. R. Lovejoy were instrumental in bringing about these advances, perhaps what was of greater importance was the enlisting of a corps of young men in electrochemistry, for they all became keen in the pursuit of the discovery of new facts and in the development of new industries.

That the scientific side might likewise be advanced the writer, then Asst. Professor, utilized the information thus gained in designing electrochemical and electric furnace laboratories for the new Chemical Laboratory of the College of the City of New York. The furnace used by Moissan at his lecture was constructed in the workshop of the Department of Chemistry, and afterwards became a highly prized piece of apparatus often used in lecture demonstration and research.

The labor of many other French chemists present at the various congresses is not forgotten, especially not those of M. François Dupont, who acted as Secretary of the Second and Fourth Congresses, whom we have to thank for the compilation of the volumes representing the work of each Congress.

In the early days of the American Chemical Society several Frenchmen, then resident in New York, were welcome members. Tessié du Motay, chemical engineer and inventor, whose oxygen and water gas processes were commercially developed in New York; M. Alexandre Bourgougnon, one time assistant to the great Chevreul at the Gobelin Tapestry Works, analyst, author, and later instructor at the College of the City of New York, and M. Auguste J. Rossi, who on coming to this country was affiliated with refrigeration processes and who has now, through amazing perseverance in the electrometallurgy of titanium and its alloys made railroad transportation safer through the addition of these alloys to steel in the process of steel rail manufacture. Numerous papers from these men are to be found in the early volumes of the Society.

To-day Héroult, not content with his splendid pioneer work on the winning of aluminium, has also turned his attention to the manufacture of steel and is longing for other worlds to conquer. He is a familiar and welcome member of our scientific and engineering societies. His electric furnaces in use in the refining of molten steel will no doubt be seen by our visitors.

And reciprocally American chemists have received particular recognition in France, as Robert Hare, inventor of the oxy-hydrogen blow-pipe, and member of the earliest chemical society, the Chemical Society of Philadelphia; as R. Ogden Doremus, who made a protracted investigation on explosives under the auspices of and with the aid of the Government; as J. Lawrence Smith, T. Sterry Hunt, George F. Barker, William McMurtrie, and Harvey W. Wiley, all past presidents of the American Chemical Society.

The deliberations of this International Congress of Applied Chemistry will be an epitome of the World's Work of to-day. Engineering enterprises like the linking of two oceans at Panama, or the construction of dams and water ways to impound and distribute water to this Metropolis or to irrigate arid lands, or to harness it for power, all feats which have been made possible by the discoveries in the cement industry; the smelting of ores of iron, copper, lead, zinc, aluminium, silver, gold and other metals; the recovery of precious metals by the cyanide process from waste; obtaining metals and chemical products by electrochemical processes; vast improvements in the use of fuel through increased knowledge on the subject of combustion, and consequently increased facility in transportation, whether on land, or water or through the air; innumerable products utilized in telegraphy, the telephone, and wireless; the manufacture of materials useful in the printers art, in photography, and for the phonograph, whereby our thoughts and actions are recorded and preserved; discoveries in textile manufactures for the preparation of the fibres not only like cotton, linen, wool and silk, but artificial substitutes for some rivalling the natural products in lustre and durability; numberless dyes with which to ornament fabrics; artificial perfumes making voyages to the Indies futile; remedies to mitigate suffering, widen the field of operative surgery, to antidote some diseases, to eradicate others; chemicals to be applied as disinfectants, or be useful in sanitation; the manufacture of explosives achieving more in peace than in war; countless products which make for greater comfort, greater enjoyment of life; everything that pertains to agriculture, whether for the fertilization of the soil, the preservation of life, vegetable or animal, the conservation of not only the land but the rational preservation of its food products so that they may be kept, transported and used with safety. The twenty-six volumes of the Congress—each Section having one to represent its activities—will attest its comprehensiveness.

But beyond these evidences of the onward march of mankind in material things comes the intellectual stimulus of such a gathering. Lavoisier, who laid the foundations of the science will seem alive; we shall listen to Bertrand discourse on the "infinitely small in biology," await the disclosure of new facts in the realm of radio-activity, a department of chemistry in which Becquerel and the Curies blazed new trails, and having run the gamut of all that pertains to realism and idealism find, no doubt, our chief enjoyment in the human side of it all, in meeting old and in making new friends.

New York City. CHARLES A. DOREMUS.

* * *

Early History of Chemistry at Columbia University and Some Early Relations Between German and American Chemists.

To the Editor of Metallurgical and Chemical Engineering.

Sir: Most of the chief functions of the coming International Congress of Applied Chemistry will be held at Columbia University. It seems fitting then to call back to our mind at this moment the early history of chemistry at Columbia University. It will also be particularly interesting to note the close intimate relation which in those days already existed between German and American chemists and which has never been disturbed ever since.

Previous to 1857 there was no institution of learning in New York which provided for instruction in practical chemistry.

At Columbia College, the New York University, and the Free Academy, lectures on chemistry of a more or less popular character were delivered to the senior classes. If a man wanted to go into the practice his only resource was to go to some of the New England or Pennsylvania colleges—or to Germany or France.

In 1857 Columbia College was transferred to Forty-ninth Street. This was the beginning of a new and greatly expanded life, embracing courses in physics, higher mathematics, astronomy, mineralogy, chemical lectures and laboratory practice.

In the Chemical Department the College was fortunate in securing the services of Charles A. Joy, Ph.D. of Göttingen, who had been trained by the great chemist and ideal instructor, Hofrath Wöhler. At that time Joy was professor of Chemistry at Union College, Schenectady. In addition to the equipment of a lecture room for class instruction he stipulated for a working laboratory. The location of the lecture room and laboratory was on the top floor of the large building in the College group. Six working tables, together with a sand bath, sink and some glass cases, practically filled the room.

Chas. A. Stetefeldt, the eminent German metallurgist, who had been Bruno Kerl's chief assistant at Clausthal, and subsequently Charles Martini were his assistants.

The following statement is abstracted from the official College catalogue.

"*Chemistry.*

"Charles A. Joy, Ph.D., Professor.

"Instruction in this department is given by lectures fully illustrated by experiments and alternated with thorough reviews and examinations. The classes frequently accompany the professor to the various manufacturing establishments of the city, where the applications of Science to the Arts can be witnessed to the best advantage.

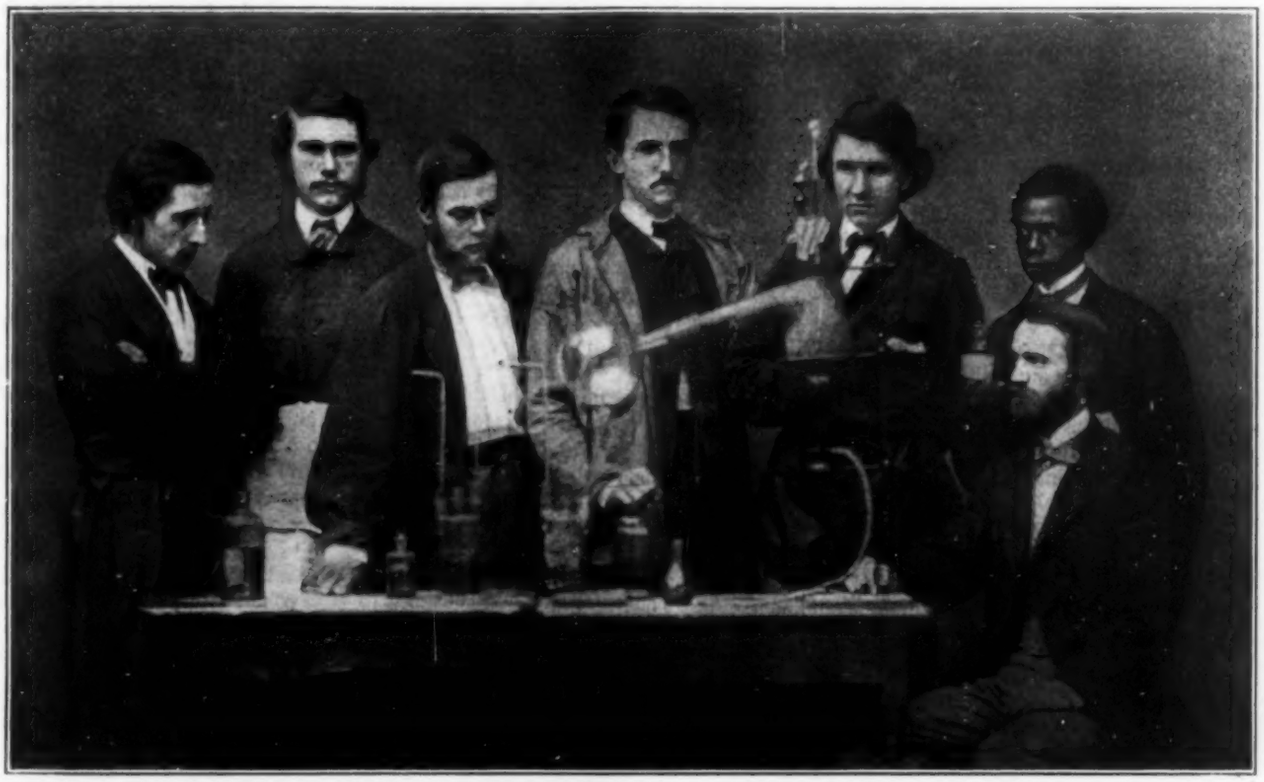
"*Practical Exercise in the Laboratory.*—The laboratory is furnished with the best modern appliances for acquiring a thorough knowledge of chemistry and the applications of this science to agriculture and the arts. It will be open to its special students from the first of November to the first of June, every week day except Saturday, from 9 a. m. until dusk at a charge of $250 a year, payable semi-annually in advance. It is designed in this school to give a complete professional education in chemistry to such as may desire it. A limited number of the most distinguished students attending the chemical lectures are admitted free of charge as working pupils into the laboratory.

"For the purpose of selecting these students, a special examination is held soon after the commencement of the second session. Students in this department have access to the College Library, to the private library of the professor, and to the scientific collection of the college.

"A prize of $100 is annually paid to the most faithful and deserving student in the laboratory."

The laboratory students during 1860 were: Anson P. Stephens, Julius Henry Tiemann, Joseph W. Alsop, Jr., Clarence Brown, Emory McClintock, Geo. M. Miller, Samuel B. Ward, Geo. W. Maynard.

But as the facilities were not adequate for rounding out a full chemical course, on the advice of Prof. Joy, Tiemann, Stephens, McClintock, and Maynard went to Göttingen, where they were so fortunate as to have as their personal instructors



CLASS OF 1860, DEPARTMENT OF CHEMISTRY, COLUMBIA COLLEGE.
From left to right: G. W. Maynard, G. M. Miller, Clarence Brown, J. W. Alsop, Jr., S. B. Ward, and Professor Joy.

those two great men Hofrath Wöhler and Dr. Beilstein. Maynard subsequently went to the Royal School of Mines at Clausthal, where that prince of teachers, Bruno Kerl, became his guide and friend.

On the return of the writer to New York at Christmas, 1863, the Columbia School of Mines was in the process of organization through the indomitable energy of Thomas Egleston, who in face of opposition finally triumphed. There was never a more beautiful example of devotion to an educational cause than was exhibited by the men who volunteered their services without pay.

It is due to Prof. Joy that Charles F. Chandler, who had succeeded Joy at Union, was induced to cast in his lot in the new venture.

Every Columbia man, in fact every chemist in the United States, knows the result, and even Göttingen has recognized his wonderful work by making him a *double* Ph.D. Can greater honor be imagined? In his bigness of heart he has recognized the small beginnings in the six-table laboratory of 1857 in the garret of the Forty-ninth Street building by showing to every new class the photograph of the students in that laboratory.

After all the great educational triumphs have been achieved through individual effort.

New York City. GEO. W. MAYNARD.

* * *

Since no complete final program is yet available while this journal is going to press, no list of papers is given here at all, since this is obviously safer than to give an incorrect list which may be misleading. A complete program of the Congress may be obtained after August 30th from the secretary of the Congress, Dr. B. C. Hesse, 25 Broad Street, New York City.

In the following we give a concise summary of the chief features of the Congress:

Washington.

The inaugural meeting of the Congress will be held on September 4th at Washington, D. C., and presided over by the President of the United States and will be followed by excursions and a reception.

New York.

General Lectures.—Four general public lectures will be held by representatives of different nations in the great hall of the College of the City of New York in the afternoons of the following days:

Friday, September 6, 4 p. m.: GABRIEL BERTRAND, of Paris, France: "Du rôle des infiniment petits chimiques en chimie biologique."

Monday, September 9th, 4 p. m.: CARL DUISBERG, of Elberfeld, Germany: "Die neuesten Arbeiten und Probleme der Chemischen Industrie."

Tuesday, September 10th, 4 p. m.: WILLIAM HENRY PERKIN, of Manchester, England: "The Permanent Fireproofing of Cotton Goods."

Wednesday, September 11th, 4 p. m.: GIACOMO CIAMICIAN, of Bologna, Italy: "La Foto Chimica dell' Avvenire."

These four lectures will be preceded by an organ recital at 3:15 and followed by an informal tea at 5 o'clock.

Two other public lectures of great general interest will be presented before several joint sections as follows:

Saturday, September 7th, 2 p. m., in the American Museum of Natural History: SAMUEL EYDE, of Kristiania, Norway: "Oxidation of atmospheric nitrogen and development of resulting industries in Norway" in a joint session of sections II, VII, Xa and Xb.

Wednesday, September 11th, 10:30 a. m., at the College of

the City of New York: H. A. Bernthsen, of Ludwigshafen-on-the-Rhine, Germany: "Synthetic Ammonia."

Professional Meetings of Sections.—The work of the Congress will be chiefly done in the meetings of the twenty-four sections. These sessions will be held on Friday, September 6, Saturday, September 7, Monday, September 9, Tuesday, September 10, Wednesday, September 11, and Thursday, September 12, in the morning from 10 to 12 and in the afternoon from 1 to 3 every day with the exception of Saturday, September 7, on which only a morning session from 10 to 12 will be held. All these sessions will be held at Columbia University.

Members attending the Congress should register at the Central Registration Bureau as soon as possible after arrival in New York, and should indicate the sections or subsections in whose deliberations they intend to take part. Each member has the right to vote upon all nominations and resolutions at the general sessions of the Congress, but he is entitled to participation in the debates and conferences of only those sections or subsections for which he has registered.

* * *

The **American Institute of Mining Engineers** will hold joint meetings with Congress section IIIa (Metallurgy and Mining) on Friday, September 6, at 10 a. m. and 1 p. m. at Columbia University and will hold a further joint meeting with Congress sections IIIa (Metallurgy and Mining), Xa (Electrochemistry) and the American Electrochemical Society on Saturday, September 7, 10 a. m. at Columbia University. The program for the joint session of Saturday is a symposium of papers on electrometallurgy.

* * *

The **American Electrochemical Society** will hold sessions on Saturday, September 7, 10 a. m. and 2 p. m., on Monday, 10 a. m. and 1 p. m., on Tuesday at 10 a. m. and 1 p. m. The session of Saturday, September 7, 10 a. m., at Columbia, will be devoted to a symposium of papers on electrometallurgy and Congress section IIIa and the American Institute of Mining Engineers will join in this session. The meeting of Saturday, September 7, at 2 p. m. will be devoted entirely to an address by Mr. Samuel Eyde on the Fixation of Atmospheric Nitrogen in Norway, and will be held in the American Museum of Natural History, jointly with Congress sections Xa, Xb, II and VII.

The meeting of the American Electrochemical Society on Monday, September 9, 10 a. m. at Columbia University will be a joint session with Xa, Xb and II and papers relating to physical chemistry will be chiefly discussed. This will be continued at the afternoon session at 1 p. m., which will be concluded by an experimental lecture by Dr. E. Weintraub on Boron.

The meeting of the American Electrochemical Society on Tuesday, September 10, 10 a. m., at Columbia, will be in conjunction with Congress section Xa (Electrochemistry) and VI (Paper) and will be devoted to a symposium of papers on the electrolysis of alkali chlorides. In the afternoon the American Electrochemical Society will hold a joint session at Columbia University with sections IIIa (Metallurgy), Xa (Electrochemistry) and XIb (Conservation).

In order to take care of the very full program, the American Electrochemical Society may find it necessary to hold some extra session, but this question has not yet been settled.

* * *

Entertainments.

In advance of the official beginning of the Congress the following informal entertainments will be held.

A reception of the Society of Chemical Industry will be held on *Saturday*, August 31, at 8:30 p. m., at the Chemists' Club. On the same evening members of the Verein Deutscher Chemiker will gather informally on the roof garden of the Hotel Astor.

For *Sunday*, September 1, the Verein Deutscher Chemiker has arranged an automobile trip to Coney Island and in the evening a concert on the roof of the New Century Theater.

On *Monday*, September 2, 10 a. m., the Verein Deutscher Chemiker will hold a business and professional meeting at Havemeyer Hall, Columbia University, where Dr. F. Raschig will speak on the scientific and technical importance of tarphenols and Dr. F. W. Frerichs on 32 years in the United States as a chemist and manufacturer. For the evening the Verein has arranged a Kommers and for the ladies a theater party.

On the same evening the Chemists' Club will give a reception at its Club House to members of the Congress speaking the Latin tongues.

On *Tuesday*, September 3, the Society of Chemical Industry will hold its business and annual meeting at the Chemists' Club. An address of welcome by the Mayor of the City of New York and the address of the retiring president, Dr. Rudolph Messel, are scheduled for this occasion.

Wednesday and Thursday are the Washington days, as noted above.

On the evening of *Thursday*, September 5, the American Institute of Chemical Engineers will hold a banquet at the Chemists' Club.

The program of entertainments during the New York days of the Congress is as follows:

Friday, September 6, 8 p. m.: Kommers to Section VIIIb by the Apotheker Verein, of New York City, 9 p. m.: Reception to Japanese delegates by Dr. and Mrs. Takamine.

Saturday, September 7, 8:30 p. m.: Reception at the Metropolitan Museum of Art in Central Park, given by the American Chemical Society to the members of the Congress.

Sunday, September 8, 10 a. m.: Boat excursion up the Hudson to Newburgh.

Monday, September 9, 7 p. m.: Garden party at Bronx Park.

Tuesday, September 10, 8:30 p. m.: Reception by the Chemists' Club to all members of the Congress at the Club House.

Wednesday, September 11, 8 p. m.: Entertainment at the Hippodrome.

Thursday, September 11, 7 p. m.: Grand banquet at the Waldorf-Astoria.

Friday, September 13, 3 p. m.: Baseball game, New York vs. St. Louis at Polo Grounds. 7 p. m.: Subscription dinner of Society of Chemical industry at the Waldorf-Astoria.

For *Saturday*, September 14, visits to the Consolidated Gas Company and the Nichols Copper Company have been arranged for the forenoon, and a visit to the Corn Products Company, the Standard Oil Company, and the Bush Terminal Company for the afternoon.

Members of the Congress are urged to register as soon as they can, beginning Tuesday morning, September 3, at Columbia University gymnasium and to receive their twenty-four volumes of the Proceedings right after registration. For this purpose they must present their membership card. To ship their twenty-four volumes of Transactions to their house or office address, messenger service and express service will be available at the gymnasium of Columbia University (messenger and express charges to be paid, of course, by the members).

If any member prefers not to make the trip to the gymnasium of Columbia University personally, he can send a messenger for registration. But in order to enable the messenger to receive the volumes of the Transactions he must present a duly signed receipt for the Transactions, since no set of the Transactions will be delivered except against a receipt duly signed by the member himself.

The first complete sets of the Transactions have now arrived from the printer and it is a pleasure to state that the twenty-four volumes are not only most interesting in their contents but are beautifully printed. Every member will, of course, be anxious to have his set of the Transactions before the Congress begins and for this reason it is important that as many members as possible should take out their sets at their earliest convenience on or after Tuesday, September 3.

Crystolon—Silicon Carbide.

The Plant of the Norton Company at Chippawa, Ontario.

By FRANCIS A. J. FITZGERALD.

In many ways the manufacture of silicon carbide is unique, the reason being that the properties of the substance itself are peculiar. If a piece of silicon carbide, consisting of an agglomeration of crystals just as they come from the furnace, is submitted to a sufficiently high temperature in an oxidizing atmosphere slow oxidation occurs, the silicon forming silica and the carbon burning to carbon monoxide gas. This may readily be shown by means of an oxy-hydrogen blow-pipe flame. If the flame is turned on the crystals for a short time and these are then examined they will be seen to be covered with minute globules of silica produced by the oxidation of the silicon carbide.

On the other hand, if the crystals of silicon carbide are heated to a sufficiently high temperature in a reducing or neutral atmosphere decomposition occurs without fusion, the silicon vaporizes and the carbon remains behind preserving the original form of the silicon carbide crystals. There is no evidence of fusion. Such an experiment may be performed in a carbon tube, which, of course, is heated electrically.

It is this peculiar property of silicon carbide which makes the conditions of manufacture unique and has thus led to the development of a furnace which to many appears at first sight rather a crude and inefficient apparatus. In most processes for the manufacture of carbides or other compounds which involve the reduction of an oxide, the resulting product is fusible and this simplifies in many ways the manufacturing process as compared with that of silicon carbide where the resulting product is infusible. In the production of a fusible material a moderately careful mixture of the reacting raw materials is satisfactory since slight inequalities or lack of homogeneity in the mixture will not cause trouble provided the proportions of the constituents are correct. The conditions of silicon carbide manufacture, however, are different.

The mixture used in the production of silicon carbide should contain theoretically 60 parts of pure silica sand and 36 parts of pure carbon. When these are thoroughly mixed and heated to a sufficiently high temperature a portion of the carbon combines with the oxygen of the silica forming carbon monoxide gas, and the silicon thus set free combines with the remainder of the carbon to form silicon carbide. During this process, however, the mixture as a whole is not fused. Certainly the sand fuses, but the volume of carbon mixed with the sand is sufficiently great to prevent the particles of silica from running together, but instead of that they react with the carbon in their neighborhood to form, first of all, a greenish-colored substance which shows no crystalline structure, and as the temperature is carried higher this is converted into the crystalline silicon carbide. There is naturally a considerable shrinkage of the mixture, for from a theoretical charge weighing 96 kg only 40 kg of silicon carbide are obtained, the remaining 56 kg disappearing as carbon monoxide gas. The mixture then shrinks, but preserves generally its original form. If the heating is continued so that the temperature is raised still further the silicon carbide is decomposed, as already described, but still there is no fusion and ultimately the carbon which was in combination with the silicon is obtained as graphite.

If a mixture containing an excess of silica is heated a reaction occurs between the silica and the silicon carbide which results in the production of silicon, and this is just what happens in those parts of a silicon carbide furnace charge where there is an excess of silica, due to lack of homogeneity in the mixture.

A consideration of these facts leads to the conclusion that it would be difficult to manufacture silicon carbide in a furnace different in general principles from the well-known form that has been used for the purpose during the past 20 years. Moreover, it is not difficult to understand that the manufacture is one requiring very considerable care in order to obtain a satisfactory product and at the same time to get as large an output as possible.

In the design of the Norton company's plant for the manufacture of "crystolon," the name given to its silicon carbide, the first consideration was the quality of product, the efficiency of the furnaces, by which is meant the output per kw-hour, the labor cost and the cost of raw materials being deemed secondary matters. This must be remembered in considering the plant in order to appreciate it fairly.

The Norton company's crystolon plant is in Chippawa, Ont., about 2 miles above the falls of Niagara. The current is supplied by the Ontario Power Company at 12,000 volts, three-phase. Since it was decided to use furnaces having a capacity of 740 kw and to install only two units, it was necessary to use transformers with suitable taps for the Scott connection so that the three-phase current is transformed to two-phase. The transformers step down the voltage to 145. The secondary bus-bars then go to induction regulators by means of which the e.m.f. at the furnaces may be raised to 215 volts or lowered to 75 volts.

The arrangement of the electrical apparatus is shown in part in Fig. 1. The current enters the building in a room next the transformer room where it goes to the main circuit breaker and where the lightning arresters are set up. The cables from the

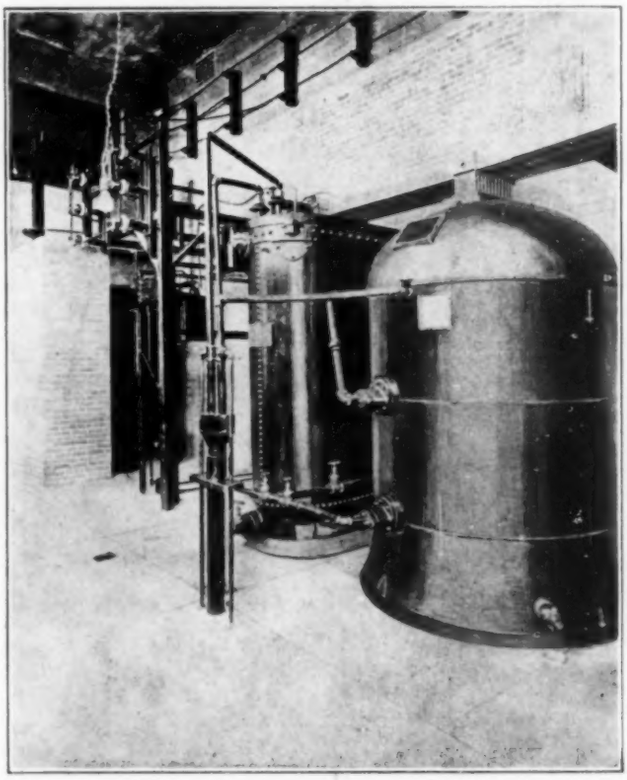


FIG. 1.—ARRANGEMENT OF ELECTRICAL APPARATUS IN CRYSTOLON PLANT OF NORTON CO.

main circuit breaker are then brought into the transformer room on brackets near the ceiling, as shown in the figure. A frame work, shown at the left, carries two single-pole double-throw switches so that the transformer, seen in the center, can be connected to any one of the three-phases. The frame work also carries circuit breakers, of which one is connected in parallel with a water rheostat and can be tripped by hand, while the other is provided with an automatic tripping device. The reason for using the water rheostat is that it is frequently necessary to throw the current on at full load and this might cause dangerous surging if the circuit was closed by means of the oil circuit breaker.

To the right of the transformer in the figure is the induction regulator by means of which the voltage of the current is raised or lowered. The induction regulator is built like an induction motor and the secondary voltage varies with the position of the rotor. Its great advantage lies in the fact that there are no contacts as in other kinds of voltage regulators and the change of voltage is perfectly continuous. The disadvantage is that on account of the air gaps between the primary and secondary there is considerable magnetic leakage, and, consequently, the power factor of the circuit is apt to be low. This, however, is more than compensated for by the advantages which make a break-down of the system highly improbable.

The busbars coming from the transformer and regulator are interlaced and pass through the wall of the transformer room to the furnace room, which they cross transversely. On either side of the busbar line are three furnaces, these forming one unit, Fig. 2. Between the terminals of each pair of furnaces on opposite sides of the busbar line bars are brought down.

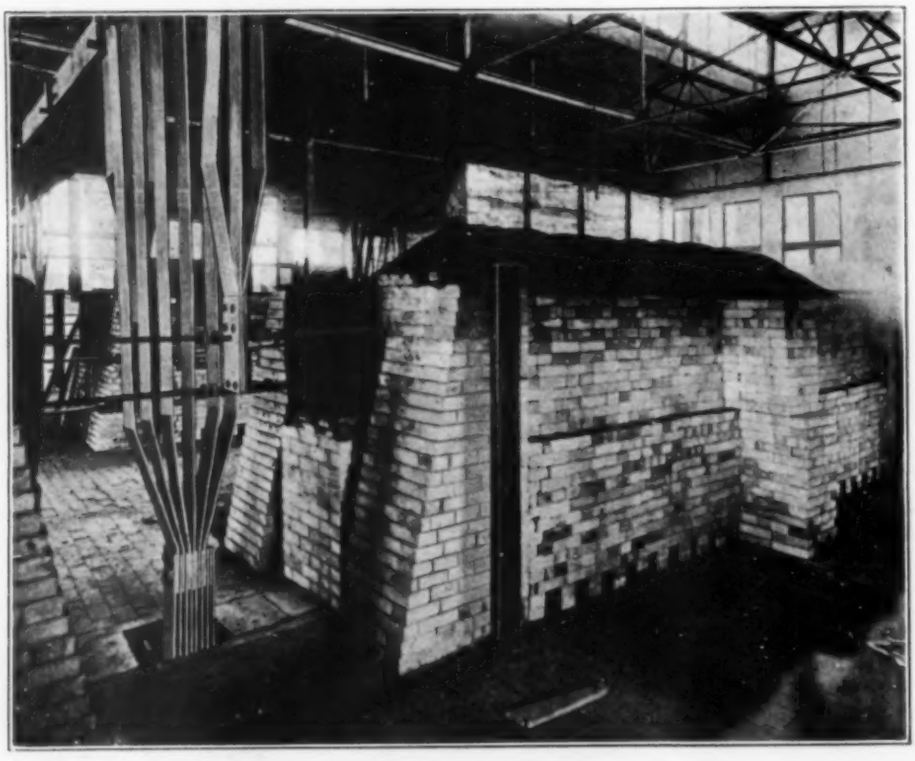


FIG. 2.—ELECTRIC FURNACES FOR MANUFACTURING CRYSTOLON.

those of one polarity going down into a concrete trough which passes under the foundations of the furnaces, the other bars terminating on a level with the furnace terminals. The bars going into the trough come out at the other ends of the furnaces and can there be connected by means of cables to the terminals as shown in Fig. 3.

The grounded ends of the furnaces, that is the terminals connected to the busbars passing through the trough, are kept permanently connected, but the other terminal is only connected to the busbars when the furnace is running. In starting a furnace the regulator is adjusted so as to have the maximum voltage at the furnace terminals and this brings the furnace to load, 700 kw, in a few minutes. The resistance still keeps dropping rapidly as the temperature rises, but by means of the regulator the rate of generation of energy is kept constant. Finally the resistance becomes very nearly constant and there is only a gradual fall to the end of the run. Although it is possible to decrease the e.m.f. at the terminals to 75 volts it is customary so to construct the furnace that the resistance at the end of the run requires an e.m.f. of about 80 volts.

It has been pointed out that an objection to the use of an induction regulator is its influence on the power factor of the circuit. It is found, however, that even with the large current of 9000 amp used at the end of the run the power factor is about 0.9.

The raw materials for the manufacture are brought in on a switch at the side of the building opposite to the transformer room. The sand and sawdust are taken from the cars and conveyed to large concrete storage bins by means of elevators. The coke is thrown directly into a crusher, and when the granular carbon for making the resistor used in the furnace is required the coke coming from the crusher is passed over screens which separates particles of the required size. The under size and over size particles of coke are carried to a buhr mill where they are finely ground and thence conveyed to a concrete storage bin.

In making the charge for the furnace a mechanical mixer is used and the mixture is emptied at once into the hand cars which convey it to the furnaces. These are built in the usual way with the mixture surrounding the granular coke resistor. The furnaces have an electrical capacity of about 700 kw.

This question is sometimes asked: "Would not larger furnaces result in more economical working?" It is a fact that the consumption of energy in a small silicon carbide furnace, say of 75 kw, is very large, about 10 kw-hours per pound, and that in going to a larger sized furnace, for example 200 kw, the reduction in energy consumption is very marked. Again increasing the size of the furnace to 700 or 800 kw makes the working still more economical, but about here a point is reached where still further increase in size is of doubtful advantage. This is easily explained when certain of the peculiarities of silicon carbide are considered.

It has already been pointed out that the substance is infusible and that it must be formed between certain temperature limits. The result of this is that when a charge has been partially converted into silicon carbide, the heating resistor is surrounded with a cylinder of the carbide and, consequently, the heat which is supplied to the charge must be conducted through this cylinder to the surrounding mixture. It is obvious that there is a limit to the thickness through which it is economical to transmit heat and that very large furnaces would demand such a great increase in the thickness of the silicon carbide cylinder that they would not be practicable. On the other hand, if the thickness of the silicon carbide cylinder is kept the same and the length of the furnace increased so as to accommodate the increased rate of generation, there is nothing gained in heat economy, since the radiating surface of the furnace is increased in proportion to the rate of generation of energy.

Another objection to very large furnaces is the increased difficulty in building with the care necessary to obtain a product of the highest quality possible. Lack of uniformity in the charge or irregularities in the resistor all tend to bring about the production of an inferior abrasive. It is for this reason that the most elaborate care is taken in the mixing of the charge and the construction of the furnaces at the "Crystolon" plant. Analyses of all the raw materials are made as soon as these are

received at the plant, then in the Chippawa factory analyses of the raw materials are made twice a day and the mixture adjusted accordingly.

The equipment of the plant is very complete both as regards apparatus and personnel for carrying on research work on the working of the furnaces and methods of manufacture. This research not only covers chemical and electrical studies but also important thermal experiments. Some of the results of this work have been published by Saunders in an interesting paper read at the last meeting of American Electrochemical Society[1] in Boston.

The temperature measurements of the crystolon furnace are of great interest in many ways. They show what exaggerated notions of the temperature of the furnace have been formerly entertained and also the comparatively small range of temperature which can be utilized in making silicon carbide. As determined by Saunders the temperature at which silicon carbide crystals begin to form is only 400 degrees below that of de-

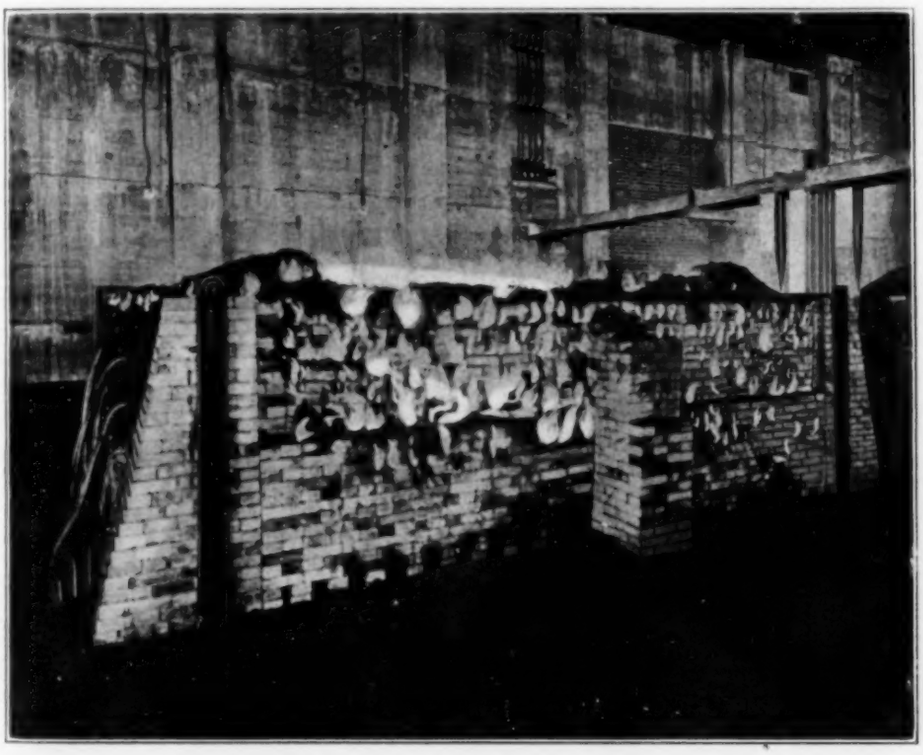


FIG. 3.—ELECTRIC FURNACE FOR MANUFACTURING CRYSTOLON.

composition. There is no doubt that for some processes 400 deg. would be a large range of temperature, but for a substance like silicon carbide, on account of its other peculiarities, outlined before in this article, it is not.

The Norton company's crystolon plant is used simply for the manufacture of silicon carbide, the material as it comes from the furnace being shipped to Worcester, where the crushing, grading and further manufacture is carried on. At first sight it might appear that the separation of the plant where the crude abrasive is manufactured from that in which it is made up into marketable form is not efficient, but experience seems to show that this view is not correct. The separating by no means interferes with active co-operation and at the same time permits of undivided attention to the production of a raw material of the highest quality without which the manufacture of a satisfactory finished article is impossible.

FitzGerald & Bennie Laboratories,
Niagara Falls, N. Y.

[1]Met. & Chemical Engineering, Vol. X, No. 5, p. 287.

By-Product Coke Ovens in America

The Koppers Oven and the U. S. Steel Corporation.

A very interesting paper on recent progress in by-product coke ovens in this country was presented before the Engineers' Society of Western Pennsylvania on May 21, by Mr. **William E. Hartman,** managing engineer of the H. Koppers Company, at Chicago. The paper is printed in full in the May issue of the *Proceedings* of the Society.

Mr. Hartman emphasized the rapidity of the by-product coke oven development, due to a large extent to the progressive action of the U. S. Steel Corporation, which, four years ago, built a plant of 280 Koppers ovens in Joliet, Ill., and has since invested about $10,000,000 more in the construction of its Gary, Indiana, and its Corey, Alabama, coke plants.

Use of Silica Material.—The technical advance in the industry is largely due to the use of silica material (with about 95 per cent SiO_2) in oven construction. This has made possible a considerable reduction in coking time. That **quick coking** time is an advantage in by-product coke oven practice, is evidenced by the experience of the last few years. It has been found that reducing the coke time from 24 hours to 16 hours for the charge results in a considerable improvement in the coke, this result being testified to by the blast furnace departments. Shortening the coking time increases the porosity of the coke without decreasing its crushing strength. The product is, therefore, better adapted for furnace use. The Koppers company has recently contracted with the Woodward Iron Company for eighty 13¼-ton ovens, with a guarantee of 15 hours' coking time, and Mr. Hartman confidently believes that there will be before long by-product coke ovens operated on 12 hours' coking time.

In connection with this reduction of the coking time, one feature, which may be regarded as the prime requisite in by-product oven coking, must not be lost sight of, that is, **absolute uniformity of heating** throughout the length of an oven, thus producing coke uniformly coked in a minimum length of time. Without this uniformity of heating, it is impossible to make any decided reduction in coking time, because of the danger of either over-coking or under-coking some of the charge, both of which faults are detrimental to the quality of the coke.

This necessity of absolute uniformity of heating throughout the length of an oven is also of especial importance with the tendency of increasing the size of the ovens. The ovens built at Joliet in 1907-1908, were designed with a capacity of 10½ tons per charge, and these were then considered large ovens. The ovens of the same type, built since this, have been 12¾ or 13¼ tons capacity per charge. The standard Koppers oven at this date is 15 tons per charge. This 15-ton oven referred to is 40 ft. long between doors, 11 ft. high, and has an average width of 19 in. This increase in oven size has an important bearing on the operating cost.

There is a similar tendency to increase the size of batteries, that is, the number of ovens built to a battery. Formerly a 50-oven battery was considered a maximum. The Steel Cor-

poration started out in its first plant at Joliet with four 70-oven batteries, and they have followed this arrangement in their Gary, Ind., and Corey, Ala., plants. However, it is worthy of notice that their Duluth, Minn., plants contemplate a battery of 92 ovens. The largest number of ovens that has ever been built in one battery is a recent installation of Koppers oven at Kaiser-Friedrich Colliery, near Dortmund, Germany. Here they have 120 ovens in one battery and they experienced no expansion difficulties in heating up the installation. It is evident that increasing the size of the battery decreases the construction cost, as well as the operating cost. There is no reason why those longer batteries cannot be successful in every way, provided proper construction precautions are taken for the expansion of the material.

First Cost.—Bee-hive ovens can be built for $700 to $800 per oven, including all machinery, while a by-product oven plant costs $12,000 to $18,000 per oven, and the oven battery itself costs about half of this. But the bee-hive oven receives a charge of perhaps 6 tons of coal every 48 hours, while the up-to-date by-product coke oven cokes its charge of 15 tons in from 15 to 18 hours. "With this sized by-product oven and this coking time, it has been found that the cost of construction of a by-product oven is about the same, or a little less than the cost of the bee-hive oven, figured on the basis of coke production. By this we mean that the cost of the by-product oven battery, including all of its machinery, piping, etc., but excluding that part of the plant for handling and recovering the by-products, compares favorably with the total cost of a battery of bee-hive ovens when figured per ton of coke produced. This may be surprising to many, but it is one of the results of the recent rapid progress in the industry, and it is only possible with a large oven coking its charge in the short time mentioned.

As to the life of by-product ovens no definite statement can be made. There are batteries that have been in operation ten years without any oven wall repairs (the walls receiving the most severe treatment). On the other hand, at a plant in England it is necessary to rebuild the oven walls about every two years, but this is an exceptional case, the coal used being high in alkaline salts which react chemically with the silica of the wall brick. For this reason a preliminary laboratory examination of coal samples is important.

Most American coals are low in alkaline salts and a reasonably long life can be assumed for oven walls. The battery of silica material at Joliet has been in operation now for about 3½ years, and to all appearances it is good for at least 3½ years more without repairs; and in this conenction it may be said that this plant in three years produced as much coke as was guaranteed and expected to be made in five years.

Kind of Coal Used and Preliminary Treatment.—Due to the Steel Corporation's experience with low volatile coal at Joliet, it has come to be generally believed that the best quality of blast furnace coke could only be made by using a low volatile coal, or mixture of coals. The coal used at Joliet was for a long time 80 per cent Pocahontas and 20 per cent Romeo, making the volatile content of the mixture about 20 per cent. More recently Illinois coal was substituted for the Ronco, and more recently still, they had a month's run of 60 per cent Pocahontas and 40 per cent Klondike. This mixture had a volatile content of about 25 per cent, and it is interesting to note that this coal mixture produced coke far superior to that formerly made. The porosity was higher and the blast furnace results were decidedly improved.

There is a by-product coke oven plant at Duluth, using in the ovens ¾-in. screenings from Pittsburgh coal. This has a volatile content of 34 or 35 per cent, and the coke gives very good results in their blast furnaces, the blast furnaces being relatively small. In Germany there are a large number of plants operating with washed coal containing from 10 to 12 per cent moisture, and from 14 to 16 per cent volatile matter. It is not generally known that coal of this kind can be used without having trouble from expansion during coking, but the Koppers Company has no such difficulties, and this is attributed largely to the fact that the coking processes take place uniformly throughout the length of the oven so that no part of the charge is over-coked. This over-coking would result in excessive formation of breeze, which would interfere with pushing the charge.

The specific gravity of the coal has an important bearing on the subject. The Koppers Company have several plants operating in England using very light coal and the volatile content is about 30 per cent. In order to make metallurgical coke from this light coal, it is necessary to compress the coal by stamping it into a cake before charging; while in this country there are a number of plants making good metallurgical coke from 30 per cent volatile coal without any such troublesome treatment of the coal before charging.

Another important characteristic of coals is the oxygen content. A coal that is high in oxygen requires a relatively high temperature and longer time for coking, and gives trouble through an excessive formation of carbon in the oven and pipes. Also, the gas yield is lower and the quality of the gas is poorer, so that all things considered it has been found that high oxygen in coal is much more objectionable than high ash content.

This country is as yet rich in coals of the first quality, requiring no washing to make them suitable for the manufacture of high-grade coke, but there are, nevertheless, a number of coals relatively high in ash and sulphur, which coals are decidedly improved by washing, and again there are coals high in ash and sulphur with these objectionable elements in such a condition that their percentage cannot be materially lowered by washing. If coals are washed they should be well drained so as to bring the percentage of water down to 7 or 8 per cent. This is not essential, but it is desirable. In many cases it is unnecessary to crush the coal very fine before washing, and in such cases the draining of the water is facilitated by the size of the coal.

In cases where it is desirable to mix two kinds of coal it is advisable to crush the coals very fine in order to get an intimate mixture of the two kinds. This crushing is usually done with hammer mill crushers, to a degree of fineness of 85 per cent through an ⅛-in. mesh screen. Also, if a coal is used containing small pieces of slate this degree of fine crushing will grind up the slate with the coal, producing a homogeneous mixture and avoiding cross fractures in the coke, which otherwise might be caused by the slate. When the coal is to be pulverized a Bradford breaker is usually installed to break up the lumps to about 1¼ in. size and to remove refuse. Following the Bradford breaker, in some instances, a magnetic separator is used to remove small iron refuse and thus protect the hammer mill crusher following next in series.

However, it is worthy of note that the largest by-product oven plant in the world, that is the Gary, Ind., plant, is preparing its coal successfully without the use of magnetic separators. In place of this they have each of the hammer mill crushers provided with a pocket which catches iron refuse and which can be dumped at intervals. The mixing of coals is most efficiently done after crushing, and usually a plant is provided with two mixing bins from which the crushed coal is fed onto belts, which belts discharge into one chute, provided with paddle-wheel mixers. The mixed coal is then elevated to a storage bin, located above and to one end of the oven battery. From this bin the charging larry is supplied.

Quenching of the coke is done in this country with the greatest amount of success in a quenching car. The coke is pushed directly from the ovens into a large open car, preferably lined with cast iron. The coke is quenched by a large overhead stream immediately after the coke falls into the car. It is advantageous to quench the coke as soon as possible after pushing in order that its heat may be sufficient to drive off excessive moisture, and experience shows that if the coke is quenched immediately after pushing it will not retain an ex-

cessive amount of moisture, no matter how large a stream of water is used. It has been found, however, that quenching the coke right at the ovens is open to objections, because of the large amount of steam produced, this steam having an injurious action on the oven steel work and brick work, as well as being disagreeable to the operators, so that the tendency now is to push the coke into such an open quenching car and immediately take this car away to be quenched at a quenching station slightly removed from the battery. In either case it is essential that the quenching steam be large in volume and quickly and thoroughly applied. By this method coke may be quenched so as to have not over 2 to 4 per cent moisture.

It has been recently suggested that quenching can be still more efficiently accomplished with lower resulting moisture if hot water is used, and the Koppers Company are experimenting along this line. The necessity for further improvement in our quenching methods is evident from the fact that one by-product coke oven plant has recently contracted for a part of its output on a moisture specification of 1 per cent.

It has only recently been demonstrated that it is poor policy to use run-of-oven coke in blast furnaces. Plants are now being equipped with facilities for screening, and in some cases for crushing and screening their product. For screening revolving screens are most efficient. The Steel Corporation's coke plant at Joliet and their blast furnaces have demonstrated to their satisfaction that it is exceedingly advantageous to use only thoroughly cleaned coke, reduced in size to 2 in. or less. This plant is not equipped with crushers, but the coke receives severe dropping treatment before it is screened, and is thus broken up just as effectively as though crushers were used. Other furnace plants around the country have arrived at the same conclusion, and are equipping themselves to reduce the size of their product for blast furnace purposes. In some cases coke is elevated for this treatment by means of belts, but the heavy maintenance incidental to this method of elevation is leading to the use of skip hoists for this purpose.

One of the great advantages of the by-product coke oven over the beehive is the **increase in coke yield.** This amounts to 5 to 10 per cent of the coal carbonized, and is due not only to the fact that there is no combustion in the coke in the by-product oven, but also to the fact that part of the heavy volatile matter in the by-product oven is converted into coke.

By-products.—The apparatus for winning and handling the by-products has been so perfected now that when a plant is started up with inexperienced men and with only one man to give them proper instructions the operation is perfectly smooth and the best quality of by-product is turned out from the start. It had been predicted that with the increasing introduction of by-product ovens the market prices of tar and ammonium sulphate would be rapidly lowered. People have been predicting this for the last ten years, and yet the fact is that prices for these products have been steadily increasing. This is explained by the rapid development of the market, due to the increasing uses for the products.

One of the recently developed fields for coke-oven tar is the use of the same in Diesel engines, and it may be interesting to some to know that engines of this type, of a capacity of 5000 hp and over, are in successful use on tar. Tar is previously treated only for the removal of water. Regarding the surplus gas it has been found that this can be advantageously used wherever gaseous fuel, either producer gas, blast-furnace gas or natural gas has found application.

Combination Ovens.—Mr. Hartman finally mentioned the adoption of "gas ovens" or "combination ovens" by a number of steel plants in Germany, the ovens being heated with blast-furnace gas, and all of the gas from the coal being used in the various departments of their steel plants. Among these applications is its use as open-hearth fuel. Germany has made more progress in this direction than this country, and has demonstrated clearly that coke-oven gas is well adapted for this purpose. In some cases they use coke-oven gas alone and in others they mix coke-oven gas with blast-furnace gas, both methods resulting in higher furnace temperatures, thus increasing the open-hearth output. It has been found that after the workmen become used to the new fuel the life of the furnace is as long with coke-oven gas as with producer gas. Among the advantages given are the following: Higher furnace temperatures, resulting in greater output; more uniform combustion resulting in greater fuel economy; elimination of the gas chambers, resulting in cheaper furnace construction; smaller repair costs; cheaper operating costs.

Discussion.

There were a number of communicated discussions. **Mr. F. F. Marquard,** superintendent of the coke works department of the South Sharon Steel Works of the Carnegie Steel Works, gave some information on their **Otto-Hofman ovens,** installed ten years ago. They are now operating their ovens on a mixture of 65 per cent Klondike and 35 per cent Pocahontas coal, having an average of 25.5 per cent volatile matter. They have steadily maintained a coking time of 24 hours, but within the past month they have reduced the coking time to 20½ hours with very encouraging results in the action of the coke on the blast furnaces. The blast furnaces, which are operating on all-Sharon by-product coke, responded immediately by increased iron yield and smoother working. The coke is slightly larger, more porous, and tougher.

The coke quality to-day is of prime importance. Thus the by-product coke of to-day, where it is made for metallurgical fuel, is far superior to the by-product coke made ten years ago; first, because the coal for making this coke has been thoroughly studied; second, the heating conditions are very much higher and uniform.

The oxygen in coal has a most deleterious effect on the quality of coke; for this reason coals which have been subjected to weathering, such as coal carried on stock piles even for as short a period as four or five weeks, have a pronounced effect upon both the quality of the gas and coke produced. The shorter the interval of time from the mines to the ovens the better the coking results will be.

The reduction of the coking time from 24 to 20½ hours has improved the quality of coke for use in the blast furnace. But at the same time the tar yield was reduced from 7 gal. per net ton of coal to 5¾ gal., and they had an increased amount of naphthalene to contend with in the house. The ammonia yield decreased with 4.75 lb. NH_3 per net ton of coal to 4.4 lb. The surplus gas yield increased from 3000 cu. ft. per net ton coal to 4600 cu. ft. The total gas was about the same, 12,000 cu. ft. per net ton. Thus it took no more gas per hour to heat the ovens on a 20½-hour coking time than it took on a 24-hour coking time. However, the higher heated walls enabled them to burn this quantity of gas more efficiently in the oven flues rather than allow same to be carried down to the regenerator below.

At South Sharon they get a yield of 76 per cent dry furnace coke and 3 per cent dry breeze from a coal mixture having 25.5 per cent volatile matter, which shows that 4.5 per cent of the volatile matter driven off in the laboratory test is converted into coke in the by-product oven, while, on the other hand, in the beehive ovens the coke yield is 3 to 6 per cent less than the results, as shown by laboratory analysis of the coals carbonized, which makes a saving in the coke yield from by-product ovens of from 7 to 10 per cent more than the coke yield from beehive ovens coking from the same coal.

Dr. Richard Moldenke, the well-known secretary of the American Foundrymen's Association, discussed briefly the **requirements of the foundrymen** as distinguished from those of the blast-furnace men as follows: "Shortening the coking time increases the porosity of the coke" is undoubtedly correct. "without decreasing its crushing strength" is open for discussion, as quite the opposite has been observed on occasion. Increasing the porosity of the coke is what the blast-

furnaceman wants, as he wishes to make all the gas he can (carbon monoxide). The foundryman, on the other hand, wants to get a coke with a minimum of cell-space as he wishes to produce complete combustion and keep it that way (carbon dioxide, with the consequent very much higher temperatures). Hence the foundry trade, with an annual consumption of possibly 1,250,000 tons of coke, will not welcome a reduction in the coking time either in the by-product or the beehive oven.

As to low or high volatile coals Dr. Moldenke said that every by-product plant has its own experience and consequent standard for volatile. One plant he knows of holds to 29 per cent, while another wants 25 per cent, and still another 30 per cent. One great advantage of the by-product system, due to the localities so far selected for business reasons, is the ability to mix the coals. In this way ideal coke conditions are obtainable, as a variety of coal markets can usually be drawn upon. At the beehive plants this is impossible. They serve only the coal mines of the region.

Mr. J. L. Haehnlen, superintendent of the By-Product Coke Oven Department of the Woodward Iron Company, Woodward, Ala., said that the further reduction of the coking time would depend on two points: first, more exact knowledge of the thermal conditions existing in the coking mass itself, at all points, during the complete cycle of coking, and, second, a better knowledge of the physical properties of the refractory materials entering into the construction of oven walls, etc.

Mr. W. O. White, of Uniontown, Pa., considered the situation from the standpoint of the individual or corporation which intends to operate a large tract of coking coal as a coke operation pure and simple (not in connection with a large steel plant). Then the question which presents itself is this: Will the return on the investment warrant by-product coke oven construction? His opinion is that the smoke which now goes to waste and denudes the country surrounding our coke regions of vegetation can be more profitably used in a regenerative type of coke oven than in a by-product oven. A plant constructed along this line would be one in which the coking period would be greatly shortened, while also there would be a very considerable excess of heat which can in many localities be converted into electrical power at a comparatively small additional cost of investment.

Dr. E. W. Parker, of the U. S. Geological Survey referred to the factors which had retarded the development of by-product coke ovens in this country—namely, first, the high cost of installation and, second, the fear that the markets for the by-products with exception of gas would be demoralized. This was feared especially in regard to tar. But there is now a large and growing demand for creosoting oil. To show that by-product coke ovens are a real success in this country he gives some figures on the gradual extensions of the Ott-Hoffman ovens at the Cambria Iron Company's plant and of the Semet-Solway Company's plant at Syracuse, N. Y.

Chemistry of Ammonia Recovery.

Mr. J. R. Campbell, chief chemist of the H. C. Frick Coke Company, of Scottdale, Pa., then presented a paper on the chemical aspects of the problem confining himself to the NH_3 yield and its various aspects.

Table No. 1.

	Lb. $(NH_4)_2SO_4$ per ton coal.	
Coal, 1.3 per cent nitrogen figured to sulphate		122.6
Ammonia yield, actual sulphate	25.0	
Nitrogen left in coke, as sulphate	78.2	
Nitrogen left in 10,000 cu. ft. gas as sulphate	12.0	
Nitrogen in tar (90 lb. per ton) as sulphate	3.5	
Nitrogen in pyridine	0.3	
Nitrogen in cyanides	0.4	119.4
Unaccounted for		3.2

Table No. 2.

	Per cent
Recovered as ammonia	20.3
Remaining in the coke	63.7
As elementary nitrogen in gas	8.1
In tar	2.9
As pyridine	0.25
As cyanide	0.3

Table No. 1 and No. 2 are taken from a paper of Mr. J. D. Pennock, chief chemist of the Semet Solvay Plants. It will be noted that the total recovery of ammonia as sulphate is only about 20 per cent. Even at its best the present practice shows considerable losses in nitrogen. On the other hand, it is stated that it is possible to recover 75 to 80 per cent of the nitrogen as NH_3 in producer gas plants where the total destruction of the coal is effected. Apparently, there is also some discrepancy between the laboratory recovery of NH_3 from destructive distillation tests and the practical yield, which has been accounted for by several hypotheses.

Mr. Campbell described how the laboratory results on destructive distillation are reported. Table 3 is a standard form and the results are on a high volatile coal with high sulphate yield.

Table No. 3.

	Per cent
Sulphur:	
(a) In coal	2.05
(b) In coke	1.53
(c) In gas	0.760
Phos.	0.004
Ash	7.600
Crucible Yield:	
(a) Muck method	65.000
(b) Tube method	71.444
Composition of Volatile Matter:	
(a) Tar	3.544
(b) Free NH_3	0.332
(c) Combined NH_3	0.112
(d) H_2O from O and H in coal	7.229
(e) CO_2	2.099
(f) H_2S	0.808
(g) C_6H_6	1.254
(h) Gas by weight	13.178
Volatile Matter:	
(a) European method	28.556
(b) American method	38.230
Fixed Carbon:	
American method	54.17
Cu ft. gas per net ton of coal:	
(a) O deg. C. and 30 in. mercury	9760
(b) 15 deg. C. and 30 in. mercury	10,370
(c) 15 deg. C. and 30 in. mercury, Inc. CO_2 and H_2S	11.010
Composition of gas:	Per cent
(a) N_2	4.70
(b) H_2	53.60
(c) CH_4	27.40
(d) Ill.	3.30
(e) CO.	11.00
Sp. gr of gas	0.34
Calorific value of gas:	
(a) B.t.u. per cu. ft. of gas, min.	516
B.t.u. per cu. ft. of gas, max.	583
(b) B.t.u. of gas per lb. of coal, min.	2517
B.t.u. of gas per lb. of coal, max.	2843
$(NH_4)_2SO_4$:	Per cent
(a) Free	1.33
(b) Combined	0.45
(c) Total	1.78
Practical Yield.	
(a) Coke	69.90

(b) Tar	3.70
(c) Sulphate	1.67
Equivalents per net ton of coal:	
(a) lb. of $(NH_4)_2SO_4$	33.4
(b) lb. of benzol	25.1
(c) Gallons of tar	7.4

Mr. Campbell then commented on the different forms of NH_3 and its recovery by the Koppers direct process. It will be noted that the NH_3 is both fixed and free. Their experience on the ordinary mixture for the coking charge is that about 80 per cent of the NH_3 is free and 20 per cent combined. From a practical standpoint the free NH_3 is that which is found in the condensed form, or what is called the weak liquor. The free NH_3 is in the form of ammonium carbonate, ammonium sulphate and free NH_3, and the fixed NH_3 is in the form of ammonium sulphate, ammonium chloride, and ammonium sulphocyanide. It is upon this principle that Koppers has devised his direct process for the plants of the U. S. Steel Corporation. By this arrangement it will be seen that only a small part of the NH_3 has to be distilled with lime in the regular way. They believe that the technical distinction between the free and fixed NH_3 is that the one is distilled over with steam without the use of lime and similar compounds added for its liberation.

In other direct processes an effort has been made to pass the gases only slightly condensed directly into the sulphuric acid saturators. This probably is the ideal direct process if it could be worked out in practice since the stills could be dispensed with altogether. There are some objections to this process as pointed out by Koppers himself and others, chief of which is the formation of HCl in the bath from the action of sulphuric acid on NH_4Cl, which acts deleteriously upon the iron piping, blowers, etc., and Koppers points out that the undecomposed NH_4Cl remaining in the ammonium sulphate may later act upon the phosphates in making fertilizers, causing the formation of HCl which attacks the sacks in which the sulphate is shipped. Further, the presence of ammonium sulpho-cyanide in the ammonium sulphate acts delerteriously upon vegetation when the sulphate is used for the manufacture of fertilizers.

Briefly the process of recovering the ammonia in the Koppers direct process is this: The gas from the ovens is delivered to the by-product building and passed through the primary water-tube coolers; here it is cooled down to approximately 25 deg. Cent.

This cooling process condenses most of the tar vapors, together with such water vapor as is driven off from the coal as charged to the ovens.

The gas is then passed through the gas exhausters to the secondary tar scrubbers; then through the reheater, in which the temperature of the gas is rinsed to about 60 deg. Cent. The gas is then passed through a sulphuric acid bath in the saturators, in which the reaction takes place between the ammonia and sulphuric acid, recovering the ammonia as ammonium sulphate.

The gas is then passed out of the saturators to the fuel gas holders and delivered from them directly to the ovens or mills for heating purposes.

The tar and water condensed out of the gas in the primary coolers is passed to separating tanks where the tar and water in the form of weak ammonia liquor is separated by the difference in their specific gravities. The weak liquor containing most of the fixed ammonia is then pumped to the stills and the ammonia vapor driven off and condensed to strong ammoniacal liquor, when it is desired to manufacture this product. However, should it be desired to recover all of the NH_3 as ammonium sulphate, the ammonium vapor from the stills is returned to the gas ahead of the primary coolers and carried with it into the sulphate saturators. It is understood that lime is added in the stills for the liberation of the fixed ammonia compounds.

The sulphate is recovered and dried in the usual way, *i.e.*, by the use of centrifuges.

TABLE 4.—CATALYTIC EFFECT OF IRON AND IRON COMPOUNDS ON THE NH_3 YIELD.

	$(NH_4)_2SO_4$ per net ton
Test No. 1—Standard sample	22.4 lb.
Test No. 2—Standard sample with 10 per cent Fe drillings	16.0 lb.
Test No. 3—Standard sample with 10 per cent flue dust	11.8 lb.
Test No. 4—Standard sample with 10 per cent FeS_2	22.6 lb.
Test No. 5—Standard sample with 10 per cent FeS	20.8 lb.

TABLE 5.—CATALYTIC EFFECT OF CALCIUM COMPOUNDS ON THE NH_3 YIELD.

	Per cent increase in $(NH_4)_2SO_4$
Test No. 1—Standard sample with 2 per cent CaO	10 to 15
Test No. 2—Standard sample with 12½ per cent $CaCO_3$	12.5
Test No. 3—Standard sample with 3 per cent $CaCl_2$	11.4

Tables 4 and 5 show the catalytic effect of certain compounds on the NH_3 yield. That on the effect of iron and iron compounds is still the subject of investigation in their research laboratory, though there apparently is not much question but that iron and its oxides exert quite an adverse effect on the NH_3 yield. It will be noted that exposing hot gases to metallic iron reduces the ammonia yield about 28½ per cent, to iron oxide, about 47 per cent and to FeS about 8 per cent. This is supposed to be brought about by the catalytic action of iron and its compounds at about 870 deg. Cent., at which the NH_3 is dissociated into its elements.

On the other hand, calcium compounds exert a catalytic effect quite to the contrary of iron compounds, having a tendency to unite H and N into NH_3. Lime itself will increase the ammonia yield as shown by Table 5, but the objection to it is that it absorbs some of the otherwise volatile sulphur in the coal, thus causing a high sulphur coke, which is not permissible for blast-furnace purposes. If enough lime is used all of the sulphur found in the coal will be retained in the coke. The objection to lime is in a measure offset by the use of limestone, since the volatile sulphur for the most part is driven off at or before the decomposition of the limestone takes place.

By the use of lime and limestone the combined ammonia is pretty well destroyed, as it is natural to suppose, tests showing a reduction of 60 per cent in the combined ammonia. The lime apparently does the same work in the mixture of coal as it does in the stills.

The increase in the ammonia yield by the use of calcium chloride is accompanied by phenomena not found in the other experiments. The free and combined ammonia practically change places, *i.e.*, there is only 20 per cent free ammonia and 80 per cent combined ammonia. Thus not only does the calcium chloride have a catalytic effect, but it also converts the free ammonia to a monium chloride, the handling of which interjects some new problems into its recovery as ammonium sulphate, which will not be discussed here.

The object of emphasizing the catalytic effect of iron on the ammonia yield causing in every instance a decrease is that it may account for the low practical yield of ammonia compared with the regular tube test in the laboratory on destructive distillation. It is readily seen that this could be brought about on account of so much iron piping around by-product coke ovens to which the hot gases are exposed.

The present ammonia yield obviously can be increased by the use of chemicals in the coking charge, as lime compounds before noted, which have a tendency to combine the elemental H and N into NH_3 instead of dissociating it. Also, it is pointed out at this time that the construction of future by-product plants may be modified in such a manner that the iron piping will not have such a catalytic effect. All these

phenomena are now being investigated carefully by the United States Steel Corporation, and if it is found that there is any weight to the hypotheses advanced advantage will be taken thereof and the desired improvements in the practice and changes in the equipment will be made.

Further Discussion.

Dr. F. Schniewind, president of the United Coke and Gas Company, of New York City, gave various data on United-Otto coke ovens in this country and the Cambria Steel Company's pioneer plant using this type of oven. He emphasized that the ideas of blast-furnace superintendents in regard to the quality of coke required have undergone material changes. For instance, the coke is now being broken before it is charged into the furnace. He also stated that if the short coking time were actually a standard of uniformity of heating, it was a fact that batteries have operated in 14 hours, not for a day but for months. This naturally greatly increases the daily capacity of a plant; but that it will also decrease the cost per ton of coke to a minimum is still to be proven. The destruction of by-product is enormous when the temperature of the ovens is carried above a certain point, and therefore the craze for big capacities may not always be conducive to highest economy. The market for the by-products has been very rapidly developed within the past few years, especially for tar products and for ammonium sulphate, and for by-product coke-oven gas. He referred to the gas distributed by the by-product coke-oven plant in Camden, N. J., through the northern part of the State of New Jersey and the gas made by the plant of the Citizens' Gas Company at Indianapolis.

Mr. R. D. Hapgood, chief chemist of the Gulick-Henderson Company, of Pittsburgh, referred to tests made by him to determine the relative strength of beehive coke and by-product coke when subjected to physical tests intended to duplicate as nearly as possible the handling of coke between the time it leaves the oven and its final consumption in the furnace. After the coke has been subjected to these crushing tests it was screened and the various sizes weighed. All coke remaining on the 1-in. screen or larger was considered furnace coke. From these tests approximately 66 to 68 per cent of furnace coke was obtained from the beehive coke, and 76 to 78 per cent from the by-product coke.

Mr. J. W. Dougherty, president of the Pittsburgh Crucible Steel Company, asked whether it would be possible in a by-product coke oven, properly designed, to make a satisfactory furnace coke from Pittsburgh vein of coal carrying 34 per cent volatile matter, assuming the coke was to be used in a furnace originally designed to produce at least 500 tons a day from Old Basin Connellsville or a good Klondike coke.

Mr. E. A. Moore, president of the American Coke and Gas Construction Company, of Camden, replied that Pittsburgh vein coal 34 per cent volatile will not make a suitable blast-furnace coke for a 500-ton furnace.

Mr. W. E. Hartman confirmed this from the past experience of the Koppers people, but stated that lately experiments indicate that high heats and short coking time are going to enlarge the possibilities of the by-product ovens very decidedly. We find that shortening the coking time improves the coke for blast furnace use and we expect within the next few weeks to make some experiments on Pittsburgh coal with short coking time. As far as we know up to date we would not say absolutely that you can use Pittsburgh coal to make coke for a 500-ton furnace, but we think there are possibilities of being worked out.

Mr. F. C. Keighley said that the installation of by-product coke ovens is almost wholly a question of time, place, and condition. There must be a market for the by-products. He thinks that the building of by-product ovens will preceed with great despatch, not so much from a coke standpoint as the seemingly great demand there is likely to be for the by-products. It is possible to coke inferior coals in by-product ovens which could not be treated profitably in beehive ovens; however, the time has not yet arrived in this country when coke manufacturers have to resort to the employment of inferior coal for coking purposes.

He also gave some data on beehive oven practice and stated that the average yield of coke from coal in the beehive oven probably runs from 64 to 66 per cent, although he has obtained a yield of 70 per cent of coke in an experimental beehive oven.

Mr. W. L. Affelder, general manager of Bulger Block Coal Company, of Bulger, Pa., emphasized the magnitude of the possibilities of the by-product coke oven by stating that at present there are about 45,000 tons of volatile matter discharged into the atmosphere every day from the coke ovens in the Connellsville coke region. As the very high first cost of the by-product coke oven often proves a prohibitive factor, reference was made to the arrangements between the Bethlehem Steel Company and a German syndicate which is putting in a by-product plant at Bethlehem; the Bethlehem Steel Company furnishes the coal and takes the coke and the gas at a price and the Germans get the balance.

Mr. J. W. Dougherty emphasized that some day natural gas will be exhausted and that unless some other gas is forced into the pipes now laid in the ground for natural gas purposes, millions of dollars of property will become worthless. With natural gas selling at 30 cents per 1000 cu. ft. for domestic purposes, it seems that the gases from which the tar and sulphate of ammonia have been extracted will become, also, a very valuable product. He ridiculed the present cry of the high cost of living while there is so much waste in the coke industry. Mr. Dougherty said that the solution would be very simple in the Pittsburgh district if satisfactory blast-furnace coke could be made from Pittsburgh coal carrying 34 per cent volatile, but since this is not yet possible, as stated above, he thinks a remedy would be to ship some low volatile coal into the Pittsburgh district so as to get a mixture containing 25 to 28 per cent volatile matter from which good furnace coke can be produced.

Mr. A. W. Belden, of the U. S. Bureau of Mines Testing Station in Pittsburgh, remarked in regard to the Bethlehem Steel Company's arrangement that the Tennessee Coal & Iron Company, of Birmingham, Ala., made that same arrangement with the Semet-Solvay Company in 1898 and the Semet-Solvay people got their money out of the by-products.

Dr. H. C. Porter, of the U. S. Bureau of Mines Testing Station of Pittsburgh, criticised Mr. Campbell's experiments in so far as they were made on a laboratory scale and, therefore, might give an exaggerated idea on the effect of iron in reducing the yield of ammonia in practice and also on the effect of lime in increasing the ammonia yield. The latter fact was discovered some years ago and in practice it has been discarded after trial on account of the slagging of the lime with the silica brick for one thing, and possibly also on account of the effect on the coke.

Mr. Irving C. Allen, of the United States Bureau of Mines Testing Station, emphasized the great possibilities of a ready market for the tar products from by-product ovens as a result of the successful experiments made in recent years with the use of heavy tar oils in Diesel engines.

Mr. W. L. Affelder asked why Pittsburgh coal contained ing 35 per cent volatile matter would not give suitable coke in a by-product oven. He acknowledged the fact, but wanted to know the reason. Is it that it will not coke in a by-product oven because the coal shrinks too much, whereas a low volatile coal expands?

Mr. E. A. Moore replied that Pittsburgh high volatile coal volatilizes so rapidly that it expands and makes a cellular structure so large and with walls so weak that when it is put into the furnace the coke is so fragile as to break down and make it very difficult to operate in driving the blast. That is the principal feature, aside from the usual high sulphur con-

tent. As a matter of fact, different coals require different heating treatments in by-product coke ovens.

In his final reply, the author, **Mr. W. E. Hartman,** stated with reference to Mr. Campbell's remarks on the lowering of ammonia yield with increased temperature and reduced coking time, that they are working on that subject and "are improving the conditions over present construction; not only attempting to keep the ascension pipe cool by water-cooling it, but we are also lowering the horizontal flue to keep the products of combustion below the gas space so that the gas space above the coal is not exposed to so much heat."

As to the statement which had been made that the Koppers ovens makes small coke and therefore Koppers says small coke is the best kind of coke to use in the blast furnace, Mr. Hartman replied that "in some cases we are putting crushers in to break the coke. I think that is all that is necessary to answer that point.

"At Joliet the coke under 1 in. is 2¾ to 3 per cent."

Mr. Hartman confirmed a statement by Mr. E. A. Moore as to the effect of wet coal on the coking time, that this "depends altogether on the moisture and the fineness of the coal when it is put into the oven and the rapidity with which you raise the heat. You can coke it just as rapidly as dry coal, but you are liable to do more or less damage to the coke if the nature of the coal is such as to enlarge the cellular structure. You are liable to produce water gas and increase the volume but reduce the heat value. Ordinarily we say it takes about three hours longer with 10 to 12 per cent moisture under normal heat conditions as compared with dry coal."

As to whether crushing coal is always an advantage Mr. Hartman said that they have lately come to the opinion which is to be proven to a greater or less extent by experience, that if the coal is clean, without slate, and is only one kind of coal and not a mixed coal, it is not so necessary to crush it fine.

Mr. J. R. Campbell in reply to Dr. Porter said that he did not wish to convey the impression that the catalytic effect of iron and certain iron compounds on the NH_3 yield accounted entirely for the low practical yield or losses of NH_3. He merely mentioned it as one of the contributing causes, and the fact that both Mr. Hartman and Mr. Koppers realize this and are endeavoring to overcome it by certain modifications in the Koppers oven is a very good proof that there is something in the claim even though all our data must necessarily be based on laboratory experiments.

Also, he did not intend to convey the impression that he had made a discovery in the use of lime to increase the NH_3 yield. He simply brought that point in to show the catalytic effect of certain elements on the NH_3 yield. However, with reference to Dr. Porter's objection to the use of lime, Mr. Campbell had never seen any ill effects from the use of crushed limestone with the coking charge either upon the oven walls or the coke itself where the limestone is judiciously used and in accordance with the laws of chemical combination. "Dr. Diehl has made a very valuable contribution to the literature on the subject in which he points out that no ill effects can take place if a mono-silicate is formed during the coking process. As it seems to me he shows conclusively that there is no danger from the slagging action upon the brick."

Several speakers in the discussion referred to the introduction of silica brick into beehive and by-product coke-oven practice and to early work done by Bradley and Kier in this direction. Mr. Campbell said that a first-class lime bond brick nowadays will not run over ¼ per cent breakage and contains usually less than 2 per cent lime. The proper designation of this class of refractories is lime-bond silica brick in distinction from clay-bond silica brick and straight fire-clay brick. There is no question but what the lime-bond brick is rapidly supplanting other kinds of refractory material where high temperatures must be maintained continuously.

In Mr. Campbell's estimation it is the only kind of material for this construction.

Zinc Ore-Dressing in Colorado.

By H. C. Parmelee.

Magnetic Separation at the Wellington Mill.

In a series of notes on this subject published in Metallurgical and Chemical Engineering in October, November and December, 1910, and February, 1911, reference was made (November, 1910, p. 620) to the proposed addition of a magnetic-separating unit at the mill of the Wellington Mines Company, Breckenridge. At that time a low-grade zinc-lead-iron middling was being stored with the expectation of treating it by magnetic separation as soon as a sufficient tonnage had been accumulated to warrant the purchase and erection of the necessary machinery. About 20,000 tons of middling was accumulated, and a magnetic-separating plant erected, which has been in operation for several months.

Herreshoff Furnace Used as Dryer.

The middling contains from 18 to 19 per cent zinc, 4 to 5 per cent lead, about 30 per cent iron, 2 per cent insoluble, and from 43 to 44 per cent sulphur. It carries, also, about 6 per cent moisture. In size it ranges from ⅜ in. to fine as delivered to the dryer, which is a five-hearth Herreshoff furnace. Originally it was planned to dry the ore by passing the hot gases from the roaster through the dryer and thus avoid the cost of fuel for this operation. Unexpected difficulties were encountered, however, which caused the plan to be abandoned. The sulphurous gases attacked the iron rabbles, especially on the two upper hearths where the ore was moist, forming iron sulphite which rapidly wore away. No doubt some sulphuric acid also was formed by catalytic action, and this added to the rapid destruction of the iron rabbles. Another bad effect noticed was that the ore on the top hearth gradually packed and formed a solid bed which could not be removed by the rabbles. As the latter wore, the bed gradually increased in thickness, and had to be barred from the hearth before new rabbles could be substituted for the old; otherwise the new rabbles would break. A set of rabbles wore out in three weeks on the upper two hearths, whereas the rabbles on the lower hearths were still in service after three months' operation, and were still good for further use. The plan of utilizing the heat of the roaster gases might prove feasible in some other form of dryer, such as an open shaft with baffles, but it is certain that the idea is not feasible where there is a possibility of chemical reaction between the sulphurous gases and metallic parts.

After abandoning the above plan, the ordinary firebox was used, burning Crested Butte (Colorado) semi-anthracite coal. This has proved to be an economical method of drying. The dryer is charged with about 32 tons of ore per day, containing 6 per cent moisture. Five hundred pounds of coal is sufficient to dry this quantity of ore, evaporating from 7½ to 8 lb. water per pound of coal. After drying the ore is ground to 14 mesh.

Effect of Roasting at High Temperature.

The roasting furnace is of the usual multiple-hearth type, but has seven hearths instead of six, the latter being more common. A peculiar feature of the roast at this mill is the unusually high temperature required. At other similar plants roasting is carried on at a temperature of from 550 to 600 deg. C., but here it has been found necessary to roast at a minimum temperature of 650 deg. C. Attempts have been made to reduce this temperature, but on each occasion the subsequent magnetic separation has been affected adversely. The high temperature is detrimental to the furnace, increasing the cost of maintenance. The rabble-arms on the lower hearths, where the heat is most intense, are rapidly attacked by sulphur. The formation of iron sulphide continues until the strength of the rabble-arm is so reduced that it has to be removed. A section of such a rabble-arm shows that the iron has been converted into iron sulphide for about half its thickness.

The roasted ore is cooled and screened. Screening is advisable for removing foreign substances and small masses of ore which may have become sintered or agglomerated in the furnace. The quantity thus removed is small, but its elimination results in uniformity in the feed to the magnetic separators and in the later classification prior to wet concentration. The cooler is a hollow cylinder, 6 ft. diameter and 16 ft. long, with a spiral vane on its inner surface. The major portion of its weight is borne by the water in which it rotates, although it has roller supports at the ends. A spray of water plays on the cooler from above to keep the surface always wet and prevent the accumulation of steam in the mill building. The machine requires but little power, as it can be turned by hand. At its present capacity of 35 tons per twenty-four hours, the ore is colled sufficiently in half the length of the cylinder, and is discharged at a temperature of about 100 deg. Fahr. This type of cooler is in use at the works of the United States Zinc Company, Pueblo, Col., and was also used in the old Economic mill at Florence during the days when chlorination of Cripple Creek ore was practised.

Magnetic Separation and Wet Concentration.

The two magnetic separators are of the Ball-Norton type, with twelve magnets of alternating polarity arranged in three sets of four magnets each. The magnets have a core of soft iron, 1 in. x 8 in. x 12 in., and are wound with 600 turns of No. 13 asbestos-covered copper wire. Each separator takes a current of 16 amp at 75 volts. The first and third sets of magnets carry 4 amps each, and the second 8 amps. The feed and separating belts travel in the same direction, the latter running between the former and the magnets, but at a higher rate of speed than the feed belt. The space between the two belts is about ½ in., and as the magnetic particles are attracted to the upper belt, they are caused to shift their position each time they pass under the magnets which are of alternating polarity. This action is supposed to be beneficial in liberating non-magnetic particles which may have become mechanically entangled in the magnetic mass. These machines have a capacity of from 25 to 30 tons each in twenty-four hours.

The magnetic-iron tailing is without present value. It contains 55 per cent iron, 1.5 per cent lead, 4 per cent zinc, 1.5 per cent insoluble, and 3 oz. silver per ton. The zinc-lead mixture is classified in a four-compartment Henderson classifier,* and concentrated on one Card and four Wilfley tables. Zinc recovery averages 65 per cent at the grade of concentrate now made. The concentrate contains 48 to 49 per cent zinc, 7 per cent iron, 2½ per cent lead, 3 per cent insoluble and 2 oz. silver per ton. The lead recovery is lower, ranging from 45 to 50 per cent, on account of the losses in the zinc and iron products. The lead concentrate contains 70 per cent lead, 7 per cent zinc, 1½ per cent iron and 14 oz. silver per ton. The figures for percentage of recovery can be regarded only as close estimates, as the plant has been in operation but a short time and no opportunity has been afforded to check the results.

A dust-collecting system prevents serious dust losses and keeps the mill clean. A No. 8 Buffalo fan draws the dust through a Cyclone collector, and all sources of dust are either connected with this system or provided with pipes leading out of the building. The collected dust is delivered to the feeder of the roaster.

We acknowledge the courtesy of Mr. R. M. Henderson, manager for the Wellington Mines Company, in furnishing the data here given.

The Eagle Mining & Milling Company.

The Battle Mountain mining district embraces a small mineralized area in the southwestern part of Eagle County, Colorado, lying north of Leadville and easterly from Kokomo and Breckenridge. This district was the scene of considerable activity in mining during the early days of Leadville's history and produced ores similar to those which characterized the Leadville district at that time. The old mining town of Gilman, high on the cliffs of Eagle River Canyon, was a mining center in those days, but at present Red Cliff is the principal town in the district.

Gold, silver and lead were the valuable metals mined in the early days of this district. Some copper was also produced. Smelting was the metallurgical process most relied on, and only high-grade ore could be mined at a profit. With the gradual exhaustion of these ores, mining suffered a decline, which was more pronounced by the fact that zinc ores were encountered in increasing quantity. Zinc was not only without value at that time, but its presence in otherwise valuable ore was a detriment to profitable mining on account of the penalty imposed by the lead smelters.

With changing industrial and metallurgical conditions zinc ore has become more and more valuable, and to-day it constitutes the principal mineral production of this district. The Iron Mask mine, formerly famous as a producer of silver-bearing lead carbonate ore, is now one of the largest zinc mines in the state of Colorado. It is located near the old town of Gilman, and controlled by the Eagle Mining & Milling Company, which also operates an 80-ton concentrating mill for the treatment of Iron Mask ore. The mill was built at Belden, in Eagle River Canyon below the mine, and is connected with it by a Bleichert tramway 1100 ft. long.

Minerals in the Crude Ore.

Iron Mask zinc ore is a mixture of the sulphides of zinc, lead and iron, with some carbonate of iron and very little silicious gangue. These minerals usually occur finely crystalline, with occasional masses of coarser crystals ⅛ in. to ¼ in. in diameter; but the latter is exceptional, and it is necessary to grind the ore to 16 mesh to separate the minerals from each other. The iron carbonate sometimes occurs in large masses of botryoidal form crystals, but is usually finely distributed. Following is the average composition of the ore as sent to the mill: Zinc, 17 per cent; iron, 30 to 32 per cent; lead, 2 to per 5 cent; sulphur, 28 to 30 per cent; insoluble, 1.5 to 2 per cent; silver, 1 to 3 oz. per ton, and gold, 0.05 oz. per ton.

The zinc mineral in this ore is marmatite, or ferriferous blende, which is a variety of sphalerite containing the combination ZnS and FeS in ratios varying from 2:1 to 5:1, the latter being more common. Analysis of a clean crystal of Iron Mask marmatite showed only 54 per cent zinc, as compared with 67 per cent in pure sphalerite. Based on the formula ZnS.FeS this marmatite would also contain 12 per cent iron and 34 per cent sulphur. It is obviously impossible to produce from this ore a zinc concentrate as free from iron as could be made from pure sphalerite associated with iron as pyrite.

The other minerals in Iron Mask ore are pyrite, siderite and galena. The precious metals occur mainly in the galena, but also in the marmatite and pyrite. The siderite occurs in varying proportions, and in sending ore to the mill care has to be taken to keep the proportion of this mineral as low as possible on account of its effect on the operation of the roasting furnaces.

Preparation of the Ore.

The coarse crushing plant is built at the loading station of the aerial tramway, near the mouth of the incline through which the ore is raised. Here the ore is crushed to ¾ in. size and transported to the mill in buckets holding 1200 lb. The tramway is operated wholly by gravity, the descending loaded bucket pulling the empty up from the unloading station at the mill. One man attends to loading the bucket and operating the brakes, the loads being dumped automatically at the lower station. Coarse crushing on one shift supplies ample ore for twenty-four hours' operation of the mill.

Fine grinding is finished at the mill. The following table gives a screen analysis of the ore as delivered to the mill, and

*Described in this Journal, Nov., 1910, p. 621, and June, 1912, p. 343.

the tonnage of the various grades, based on a total of 80 tons per day:

On ⅛-in mesh	83.2 per cent	66.5 tons.
Through ⅛-in. and on 16 mesh	6.5 per cent	5.2 tons.
Through 16 mesh	10.3 per cent	8.3 tons.
	100.0 per cent	80.0 tons.

The ore is first screened into three sizes: (1) a finished product passing 16-mesh screen; (2) a size between 16-mesh and ⅛ in., which is reground in the fine rolls, and (3) the oversize of ⅛ in. which goes to the coarse rolls. All roll products are elevated and again passed over the screen. Midvale steel roll-shells on both coarse and fine rolls have given service for about two years, the former wearing a little longer than the latter.

The screen is stationary and inclined at an angle of 42 deg. It is built of removable sections, 22 in. by 20 in., after the manner of the Edison and Rowand types. Each section has an available screen area of 18 in. by 18 in. They are arranged in seven rows of three sections each, giving a screen frame about 5 ft. wide and 13 ft. long in the direction of inclination. The first five rows are 16 mesh and the last two are ⅛-in. mesh. This gives an available area of 33.75 sq. ft. of 16-mesh screen and 13.5 sq. ft. of ⅛-in. screen. Both ton-cap and punched-slot screen have been used. The former show slightly greater capacity, but the latter have given longer service and more accurate grading.

Roasting and Magnetic Separation.

As the ore contains only 1½ per cent moisture it is not dried before roasting. Two six-hearth roasters have a capacity of 40 tons per day each. The temperature of the roast is kept quite uniform at a maximum of 550 to 560 deg. C. on the third hearth from the bottom, and 525 to 535 deg. C. on the bottom hearth. Three forms of rabble blades are used: in-throwing, out-throwing and mixing. The two latter are used on those hearths having a peripheral discharge, one out-throwing blade being hung on each arm next to the vertical shaft, with mixing blades on the remainder of the arm. The single out-throwing blade is necessary to prevent the ore from piling up around the central ring as it falls from the hearth above, but the centrifugal force of the mixing blades is sufficient to move the ore over the remainder of the hearth. The siderite in the ore has a tendency to reduce the temperature of the roast, and if too much of that mineral is present the temperature is lowered to a degree at which the iron minerals are not rendered sufficiently magnetic to be removed later by the magnetic separators. For this reason care is exercised to keep the proportion of siderite in the ore as low as possible. Following is a comparative analysis of a lot of crude ore and the same ore after roasting:

	Crude.	Roasted.
Zinc, per cent	16.9	21.3
Iron, per cent	31.7	33.2
Sulphur, per cent	26.6	22.2

The roasted ore is cooled in a revolving iron cylinder fitted with tires running on rollers. A series of blades in the form of an interrupted helix on its inner surfaces moves the ore gradually from feed to discharge end. Water is distributed over the outer surface of the cylinder from launders supported above it.

Two Cleveland-Knowles magnetic separators formerly were used, but have been superseded by one separator of the Ball-Norton type, similar to those in the Wellington mill. This machine is run at much greater capacity than those at the Wellington mill, for it treats the entire roasted product from 75 or 80 tons of crude ore daily. Probably better work could be done if two machines were used, but even with one the grade of zinc concentrate has been raised several per cent above that obtained with the old machines. This has been due to a cleaner magnetic separation of the iron, which is ascribed to the better facilities afforded in the Ball-Norton machine for the release of non-magnetic particles which have become mechanically entrained in the magnetic mass.

The magnetic-iron tailing from the Ball-Norton machine is reground in a sample-grinder and run through one of the Cleveland-Knowles machines to make a further separation of any zinc-lead mineral which may have escaped separation in the first operation. The iron product is practically without value. Occasionally a lot of ore will have sufficient silver in the pyrite to make it worth smelting, but generally it is stacked on the tailing pile. It contains, on an average, 45 per cent iron, 20 per cent sulphur, 6 to 8 per cent zinc, 1 per cent lead, 1½ per cent insoluble, 0.07 oz. gold, and 1½ oz. silver per ton.

The zinc-lead concentrates from the two magnetic separators are combined, mixed with water and screened through a 30-mesh Bunker Hill screen. Sizing was substituted for classification in this case because the material was almost wholly

80-TON CONCENTRATING MILL OF THE EAGLE MINING AND MILLING COMPANY, NEAR RED CLIFF, COLO.

composed of two minerals, with practically no gangue. It is possible, however, that the use of the launder system of classification with a jig compartment, proposed by Mr. Frank E. Shepard in this journal (April, 1912, p. 218), would increase the saving of galena and improve the work of the tables. At present, however, the two screen sizes are distributed to Card tables, where the zinc and lead concentrates are separated. There is no regrinding or re-treatment of middlings, and practically no silicious tailing to be separated.

Zinc recovery averages 70 per cent, and the concentrate contains an average of 47 to 48 per cent zinc. A recent shipment analyzed as follows: 49.3 per cent zinc, 13.1 per cent iron, 0.07 per cent manganese, 1.9 per cent lead, 0.08 per cent lime (CaO), 2.0 per cent insoluble.

The lead concentrate contains, on an average, 70 per cent lead, 6½ per cent zinc, 2 per cent iron, 0.20 oz. gold and 20 oz. silver per ton.

The daily production of the mill averages 20 tons of zinc concentrate and 3 tons of lead concentrate, showing a concentration ratio of 3½ to 1.

Labor and Power.

The labor regularly required is distributed as follows: Coarse crushing and aerial transportation, one shift, two men; milling, three shifts, one general superintendent, three foremen, three tablemen, one engineer, one repairman and two loaders.

The entire mill, coarse crushing machinery and one air compressor are operated by water-power developed by a 24-in. Pelton wheel. Water is brought to the mill through a 3200-ft. pipeline under a head of 600 ft., corresponding to a pressure

of 250 lb. per square inch at the wheel. Water-power is available throughout the year, but an auxiliary steam-power equipment is at hand ready for immediate use in case the water fails.

Sampling.

The work of the mill is checked by daily assays of samples of the crude ore and products. A Scobey sampler is placed over the roaster hoppers, and a hand sample taken from each bucket of ore sent over the tramway. Half-hourly samples are taken of the iron and zinc products of the magnetic separators, and of the zinc and lead concentrates from the Card tables.

Cleanliness and order mark the work at this mill. There is little dust, considering that the ore is handled dry through the various steps to the final wet dressing. The design has been adapted to a mill site that presented some unusual difficulties, and all the machines are readily accessible and easily inspected. For over two years the results have shown a degree of regularity in tonnage and grade of products that indicates careful handling.

To Mr. S. N. Hicks and Mr. C. H. Hanington, of Denver, who control the Eagle Mining & Milling Company, our thanks are due for the information here given.

Table of Melting Points of Chemical Elements

In Circular No. 35 of June 15, 1912, of the Bureau of Standards of Washington, D. C., a table of the melting points of chemical elements is given.

The values of the melting points used by the Bureau of Standards as standard temperatures for the calibration of thermometers and pyrometers are indicated by *italics*. The other values have been assigned after a careful survey of all the available data.

As nearly as may be, all values, in particular the standard points have been reduced to a common scale, the thermodynamic scale. For high temperatures, and for use with optical pyrometers, this scale is satisfied very exactly by taking $c_2 = 14{,}500$ in the formula for Wien's law connecting I, monochromatic luminous intensity of wave length λ and T, absolute temperature: $\log I/I_1 = c_2\lambda \log e \ (I/T_1 - I/T)$. For all purposes, except the most accurate investigations, the thermodynamic scale is identical with any of the gas scales.

Element	Deg. F.	Deg. C.
Helium	Below −456	Below −271
Hydrogen	−434	−259
Neon	−423	−253?
Fluorine	−369	−223
Oxygen	−360	−218
Nitrogen	−346	−210
Argon	−306	−188
Krypton	−272	−169
Xenox	−220	−140
Chlorine	−150.5	−101.5
Mercury	− 37.7	− 38.7
Bromine	+ 18.9	− 7.3
Caesium	+ 79.	+ 26
Gallium	86	30
Rubidium	100	38
Phosphorus	111.4	44
Potassium	144	62.3
Sodium	207.5	97.5
Iodine	236.5	113.5
Sulphur S_1	235.0	112.8
S_2	246.6	119.2
S_3	224.2	106.8
Indium	311	155
Lithium	367	186
Selenium	422−428	217−220
Tin	449.4	231.9
Bismuth	520	271
Thallium	576	302
Cadmium	609.6	320.9
Lead	621.1	327.4
Zinc	786.9	419.4
Tellurium	846	452
Antimony	1166	630.0
Cerium	1184	640
Magnesium	1204	651
Aluminium	1217.7	658.7
Calcium	1490	810
Lanthanum	1490	810
Strontium	.....	Above Ca Below Ba?
Neodymium	1544	840?
Arsenic	1560	850?
Barium	1560	850?
Praseodymium	1725	940?
Germanium	1756	958
Silver	1761	960.5
Glucinum	.....	Above Ag
Radium	.....	?
Gold	1945.5	1063.0
Copper	1981.5	1083.0
Manganese	2237	1225
Yttrium	.....	?
Samarium	2370−2550	1300−1400
Scandium	.....	?
Silicon	2588	1420
Nickel	2646	1452
Cobalt	2714	1490
Chromium	2750	1510
Iron	2768	1520
Palladium	2820	1549
Zirconium	3100	1700?
Thorium	Above 3090 Below Pt.	Above 1700 Below Pt.
Vanadium	3150	1730?
Platinum	3191	1755
Beryllium	Above 3270	Above 1800?
Ytterbium	.....	?
Titanium	3450	1900?
Rhodium	3525	1940
Ruthenium	Above 3550	Above 1950
Columbium (Niobium)	4000	2200?
Boron	4000−4500	2200−2500
Iridium	4170	2300?
Uranium	.....	?
Molybdenum	4500	2500?
Osmium	4900	2700?
Tantalum	5160	2850
Tungsten	5430	3000
Carbon	Above 6500 for P-1 At.	Above 3600 for P-1 At.

Brittleness in gold-bullion bars, which is caused by the presence of small quanities of sulphur, may be entirely removed by re-melting the bullion bars and stirring with an iron rod until the rod ceases to be thinned at the end which is immersed in the molten bullion.

The percentage of bullion (sponge gold) in well squeezed or pressed amalgam depends principally on the state of division of the gold before it was amalgamated. Where the gold is coarse, and when ordinary amalgamating tables are used, the mercury does not penetrate far into the gold. Well cleaned and pressed amalgam sometimes yields well under 18 per cent sponge gold where the gold exists naturally in a very fine state of division, or when hard and granular amalgam has been subjected to prolonged grinding with more mercury. Under these conditions the freshly cleaned and pressed amalgam is soft and buttery.

The Modern Dry Cell, Its Development, Construction and Manufacture

BY H. K. RICHARDSON.

The common dry cell, while a small thing in itself, is the basis of a very large industry, and thus has many points of interest for the electrochemist.

The magnitude of the industry is little appreciated by those not familiar with it. At the present time it is probable that 50,000,000 of the standard 2½ x 6 in. size; 5,000,000 of the complete flashlight batteries, consisting of about 15,000,000 single cells, mostly 2 5/16 in. high by 13/16 in. in diameter; and a large number (approximately 2,000,000) of special sizes and shapes are made in this country each year. Probably an equal number are made abroad.

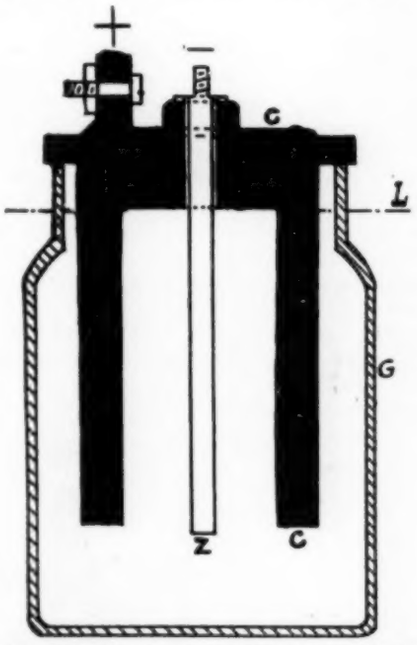


FIG. 1.—CROSS SECTION OF SALAMMONIAC PRIMARY CELL. (G, GLASS CONTAINER; C, CARBON CYLINDER; Z, ZINC POLE; L, SOLUTION LEVEL.)

The monetary value of a year's production in this country is not far from $10,000,000. The financial importance of the industry is thus considerably greater than the combined value of the four well-known electrochemical industries of carborundum, alundum, artificial graphite and aluminium manufacture. The combined value of the products of these four industries in 1909 was about $6,000,000.

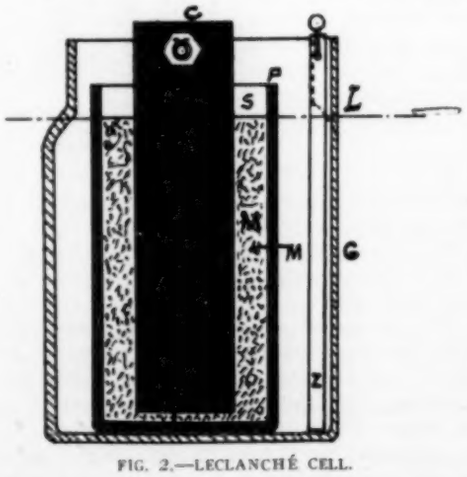


FIG. 2.—LECLANCHÉ CELL.

The production of these cells, due to the simple nature of the process of manufacture, is in the hands of forty or more separate manufacturers. The largest of these manufacturers probably makes at least one-third of the total production.

The development of the present type of cell is easily traced from the record of primary cell patents. In the description which follows only those changes will be described that have contributed materially to the improvement of cell construction.

The modern dry cell is an outgrowth of the familiar zinc-sal ammoniac-carbon ($Zn - NH_4Cl - C$) cell.

A cross section of this cell is given in Fig. 1.

The distinguishing feature of this cell is the large carbon pole and the small zinc pole.

To increase the holding-up power of this type of cell, Le clanché brought out in 1868 a cell using manganese dioxide as depolarizer. The so-called Disque Leclanché is the best representative of this kind of cell. A cross section of one of these cells is given in Fig. 2.

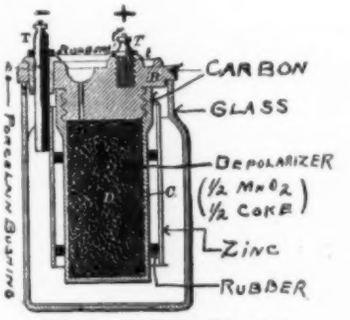


FIG. 3.—HAYDEN CUP CELL.

The noticeable features of this cell are the reduction in size of the carbon pole; the use of manganese dioxide as depolarizer; and the use of a porous porcelain cup as the container for the depolarizing mixture of manganese dioxide and ground carbon or coke.

The next important improvement in cell construction was the introduction of the Hayden cup cell. Fig. 3 shows a cross section of this type of cell.

The improvements to be noted in this cell are the substitution of a porous carbon cup (C) for the porous porcelain cup of the Leclanché cell as the container for the depolarizing mixture of manganese dioxide and carbon, and the use of a large circular zinc closely surrounding the hollow carbon cup as the negative pole. The small distance between the carbon and zinc poles gives a cell with a smaller internal resistance than any previously made.

After the introduction of the above mentioned cell inventors busied themselves with schemes to render the cell electrolyte unspillable. From the experience gained by many fanciful and dubious experiments the first successful dry cell resulted. This cell was brought out by Gassner about 1883. Fig 4 is a cross section of one of these cells.

The features to be noted in these cells are the use of the zinc pole as the container; the use of the cheese cloth as the container for the depolarizing mixture, and the use of the plaster of paris mixture to render the electrolyte unspillable.

These cells were high in internal resistance, they seldom gave over six (6) amperes on short circuit, and were low in voltage, about 1.3 volts. To improve both of these qualities the present type of cell was developed. To-day the majority of dry cells are made according to the cross section of the cell shown in Fig. 5.

This cell consists essentially of three parts:

(1) The negative pole or zinc container,

(2) The paper or porous partition between the positive and negative poles.

(3) The positive pole of two components,

(a)—a *carbon rod* surrounded by

(b)—a *mix* of manganese dioxide, ground carbon, and electrolyte.

The details of construction of these various parts follows.

Negative Pole—Zinc Container

The zinc container is made of sheet zinc; for the ordinary size (2½ x 6") cell, No. 10 rolled zinc 0.020" thick is commonly used.

This zinc is tested for lead and iron. One brand in common use tests as follows:

Lead.....	0.16 to 0.37%	Average.....	0.27%
Iron	0.003 to 0.022%	Average.....	0.013%

The presence of lead in the zinc is not as serious an objection as is commonly supposed, for its overvoltage is enough to prevent local action. In fact lead if present to less than a certain percentage seems to benefit the shelf life of the cells. By shelf life is meant the length of time that the short-circuit amperage of the cells is over ten (10). The percentage of iron must, however, be kept low.

Paper.—The kind of paper in use varies considerably with the manufacturer, some preferring three layers of thin blotting paper while others use a single layer of heavy pulpboard. The paper mostly used is a forty point (0.040 inch thick) pulpboard made up of approximately 75% ground wood and 25% sulphite fibre.

The function of the paper is twofold; a reservoir for the electrolyte, and a means of separating the positive and negative poles. Thus a paper to be satisfactory for dry-cell work must be capable of absorbing many times its own weight of liquid (the ordinary paper absorbs about 150% of its own weight of water) and the pores be so small that the finest particles of the ground carbon will not be drawn through it by colloidal migration or capillary attraction to the zinc pole. If this latter point is not taken care of, a high-resistance short-circuit is formed between the carbon and zinc poles which results in the cell slowly running down even while on open circuit.

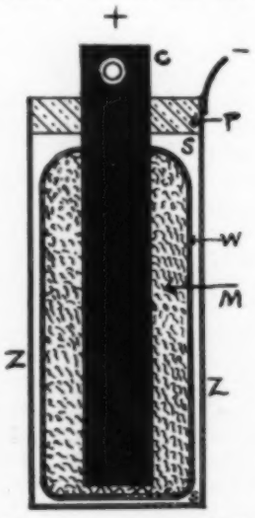


FIG. 4.—CROSS SECTION OF GASSNER CELL.

Positive Pole.

The positive pole, contrary to the usual idea, is not the piece of carbon that holds the connector, but is all the material that is contained within the paper partition, that is, it consists of

A—A mix of ground carbon, manganese dioxide, and electrolyte.

B—A carbon plug (a plate or rod).

A—The Mix.—The composition of the "mix" as used in the majority of the factories probably does not vary much from the following formula:

Pyrolusite—85% manganese dioxide.....	100	parts
Ground coke.....	80	"
Artificial graphite	20	"
Salammoniac—NH_4Cl	20	"
Zinc chloride—10 to 12 qts. 30° Be'.....	7	" approx.

The usual grade of pyrolusite tests over 85% MnO_2 and less than 1% Fe. The most commonly used grades are the Caucasian from the Caucasian Mountains, Russia, and the Japanese from Japan. In the factory parlance these are called Caucasian or Japanese "manganese."

The ground carbon used is obtained by grinding up the so-called retort coke, *i.e.*, the carbon deposited at the top of the retort in gas manufacture by the "cracking up" of the hydrocarbons. Carbon scrap free from copper is also used. In either case the material is freed from iron particles by a magnetic separator. The fineness of the grinding depends upon many factors and is usually different in different factories.

The graphite in use is mostly Acheson graphite Ba2. A few manufacturers use natural flake graphite.

The best of salammoniac is used and usually tests over 99% NH_4Cl and is free from sodium chloride and sulphate.

The zinc chloride used is that grade employed for the preserving of wood. A sample of this material analyzed:

Zinc chloride	91.6%
Manganese "	1.9
Magnesium "	1.2
Calcium "	1.1
Sodium "	0.1
Zinc oxide	2.0
Insoluble	1.5
	99.4%

The function of the various materials of the mix are as follows: The manganese dioxide is, of course, the depolarizer. The ground carbon next to the paper lining collects the current at the periphery of the "mix" and conducts it by means of the other carbon particles to the center carbon plug. The plug thus serves only to connect the mix to the outside circuit. The graphite is used to reduce the internal resistance. The salammoniac is the electrolyte while the zinc chloride is used only to improve the shelf life, *i.e.*, to reduce the local action.

B—Carbon Plug.—The carbon plug varies in shape according to the fancy of the manufacturer, the various shapes being designed to prevent the plug working loose in the mix. A few of the different shapes in use to-day are sketched below.

There are various means used to connect to the carbon plug. With plugs of the shape of numbers 1, 2, 4 and 7 in Fig. 6 the connection is usually a brass bolt, nut and knurl. In the case of number 3 the connection is made by drilling a vertical hole in the carbon, filling it with hot solder (*S*) and inserting therein a brass screw (*B*), and allowing all to cool. The solder then anchors the screw; a nut and knurl completes the connector. Numbers 5 and 6 have brass cap connectors which are forced onto the top of the carbon by hammering. Number 6 with a knurl is a common type found on the market. Number 5 is used with the so-called wireless battery box or in any case where a soldered connection is needed. The tops of all carbon plugs are soaked in paraffin to prevent the electrolyte from being sucked up to and corroding the brass connector.

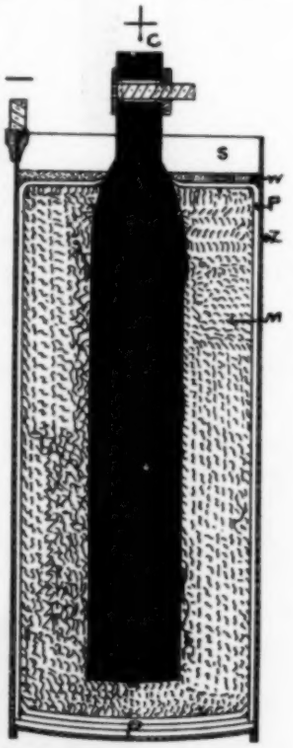


FIG. 5.—PRESENT TYPE OF DRY CELL.

Most all cells use a simple brass post and knurl to make connection to the zinc container. Cells made for the wireless battery box have the upper third of the zinc container formed into threads that screw into the box receptacle.

During the process of manufacture there are a few precautions that need to be taken. No large pieces of metal can be allowed to get into the mix or short circuits will result from torn linings. A small amount of finely divided copper is the worst enemy of the dry cell manufacturer as only 0.02% copper to carbon has been known to ruin a cell in two months. It was at one time supposed that if any solder got inside of the zinc can local action would result. Experiments have proven that there is no such effect. This is explained by the fact that the overvoltage of the tin of the solder is so high that

Process of Manufacture of a 2½ by 6" Cell
Outline of Operations

MIX
Pyro-lusite
Carbon
Graphite
Sal-Ammoniac
Zinc Chloride
ground to size
made up to a 30° Baume Solution
Weighed out according to formula
(*) Mixed thoroughly DRY
Zinc chloride solution added
Mixed thoroughly WET
CAN MANUFACTURE
Sheet Zinc
Rolled to cylinder
Side lap seam soldered
Cupped bottom inserted and soldered
Can (Z) tested for leaks
ASSEMBLY
Paper lining (P) inserted in can
Carbon plug (C) centered to can
Mix (M) tamped around the plug
Paper lining turned down over mix at (W)
Brass connector soldered to zinc can
Cell allowed to stand 24 hours
Tested for current and voltage
Sand (W) sprinkled over the turned down paper
Pitch seal (S) poured over sand
Connections applied to carbon plug
Cell dipped into insulating paint
Allowed to stand two weeks
Inspected for all defects and tested for current and voltage
Put into paper jacket
Packed for market

(*) Some manufacturers prefer to saturate hot zinc chloride solution with the sal ammoniac and add the same to the dry mix.
All references in ( ) are to Fig. 5.

no hydrogen can be liberated on open circuit. Zinc chloride is so deliquescent that on very humid days the mix will take up

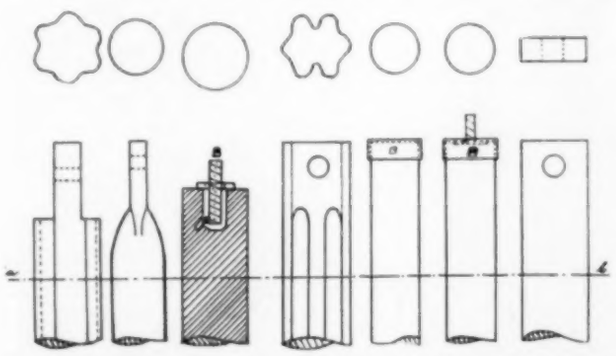


FIG. 6.—DIFFERENT SHAPES OF CARBON PLUGS. ALL VERTICAL VIEWS WITH EXCOPTION OF NO. 3, WHICH IS A CROSS SECTION, THE UPPER DIAGRAMS ARE SECTIONS OF THE PLUGS IN THE MIX, ALONG LINE A-B IN THE LOWER DIAGRAM.

water and the cells go "wet." If the trouble gets too bad the surplus water must be absorbed with sawdust before sealing the cell or the cell is likely to ooze out when put on service.

From the above table it is seen that the greatest item of expense is the zinc container, a reduction in the thickness of which would reduce the service obtainable from the cell.

The total cost as given above is probably the lowest limit to which the cost of manufacture can be pushed under present conditions. It probably represents the cost of about one-third of the present yearly production.

As very little machinery is needed for the manufacture of a dry cell and the cost of the materials per cell is so low, approximately six and one-half cents, relatively little capital is necessary for a small plant. Thus the reason for the existence of the present large number of small plants can be easily understood.

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Analysis of Cost of Manufacture

Materials	Costs Per Pound Cents	Cost Per Cell Cents	Percentage %	
Manganese Dioxide	2.00	1.00	15.8	
Ground Coke	0.75	0.30	4.7	
Graphite	2.00	0.20	3.2	Per
Sal-ammoniac	6.63	0.66	10.4	Cent.
Zinc Chloride	5.00	0.30	4.7	of
Zinc (Sheet)	7.50	2.07	32.7	Mate-
Pulpboard	3.00	0.15	2.4	rial
Carbon Plugs	....	0.35	5.5	Cost
Connections (Brass)	....	0.80	12.6	
Miscellaneous	....	0.50	7.9	
Total Material Cost		6.33	= 81% Total Mfg. Cost	
Total Factory Labor		1.50	= 19% " "	
Total Manufacturing Cost		7.83		

Melting Points of Fire Bricks.—In the *Journal* of the Franklin Institute of August on account is given of an investigation carried out at the Bureau of Standards by C. W. Kanolt on the melting points of fire bricks. The melting point is designed for this purpose as the lowest temperature at which a small piece of the brick can be seen to change from a rigid to a fluid state. The experiments were made in a resistance vacuum furnace. The samples, which were from one to two centimeters in diameter, were heated at the rate of about 10 deg. per minute when near the melting point. It was found that in the case of certain bricks made of heterogeneous material of relatively low melting point the melting points were slightly higher after six hours' heating to 1550 deg., apparently as the result of the gradual running together of dissimilar particles to form a mixture having a higher melting point that the most fusible of the original materials.

The results are summarized in the following table:

Material.	Number of Sample.	Melting point. Centigrade.
Fire Clay brick	41	1555 deg. to 1725 deg. mean 1649 deg.
Bauxite brick	8	1565 deg. to 1785 deg.
Silica brick	3	1700 deg. to 1705 deg.
Chromite brick	1	2050 deg.
Magnesia brick	1	2165 deg.
Kaolin	3	1735 deg. to 1740 deg.
Bauxite	1	1820 deg.
Bauxite clay	1	1795 deg.
Chromite	1	2180 deg.
Pure alumina		2010 deg.
Pure Silica		1750 deg.

The value 1750 deg. given for silica is not the true melting point, but represents approximately the temperature at which the silica flows distinctly. It was found that silicon carbide does not melt below 2700 deg.; it becomes unstable at much lower temperatures.

Gold and silver of good fineness may be recovered from matte by melting the roughly broken matte, then adding iron, the quantity of which should be deduced from a preliminary trial.

Graphite crucibles, if free from slag, can be assayed very accurately by roasting the crushed sample in a roasting dish with a little copper oxide, stirring well during the roasting operation. In this way all graphite is burnt away. The copper is then dissolved out from the roasted sample, and the material remaining, now only fireclay and precious metals, is fire-assayed in the usual way.

Radiation Pyrometry—V.

By G. A. Shook.

Relation Between Black Body Temperature and True Temperature.— In the preceding articles of this series the laws of "black body radiation" have been developed and have been applied to practical pyrometry. It has been shown that the "temperature" of an incandescent object, as determined by means of a radiation pyrometer calibrated against a black body, is not the *true* temperature of the object, but the so-called *black body temperature* unless the object is itself a black body.

Thus when a temperature observation is made on a stream of flowing iron or on a sheet of incandescent iron the value of the temperature thus obtained is always somewhat *lower* than the true or thermo dynamic temperature. If, however, the metal is in the interior of a uniformly heated furnace, the pyrometer then indicates the true temperature of the metal.

At first sight it might seem that this is a formidable objection to all radiation methods. Fortunately, however, in industrial practice, black body conditions are not difficult to realize so that the errors caused by this lowering of the true temperature are not significant.

Again it is apparent that if the radiation pyrometer is always used under the same conditions the scale will still be consistent. For example, in giving the temperature of an ingot of iron, it should be expressed in *black body degrees centigrade* and not merely *degrees centigrade*. If, however, we are considering the temperature of iron in an open-hearth furnace, it can be expressed on the centigrade scale. Obviously, the two temperatures obtained under the two conditions could not be used interchangeably in any calculation involving an accurate determination of the temperature.

Under certain conditions of observations it is possible to determine the true temperature of a body even though the latter is not within a uniformly heated enclosure.

Consider a shell of any material whatever, maintained at a constant uniform temperature throughout (Fig. 1.). Let us

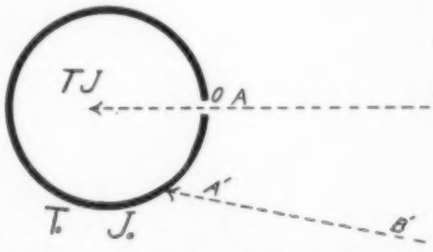

FIG. 1.—UNIFORMILY HEATED ENCLOSURE.

suppose that a small hole O, is made in one side of the shell so that a temperature observation can be made of the interior by means of an optical pyrometer. If a pyrometer is sighted in the direction AB, the true temperature of the shell can be determined. If it is sighted on the outside of the shell as in the direction A^1B^1, the black body temperature can be determined.

Let J be the intensity of the radiation emanating from the interior and T the corresponding temperature of the interior. Also let J_0 represent the intensity of the radiation from the exterior and T_0 the corresponding temperature. T is the true temperature and T_0 the corresponding black body temperature. If one should look in the direction AB, the area of the incandescant surface outlined by the contour of the hole would appear much brighter than the surrounding area.

Applying Wien's distribution law to the two cases of observation, we have

$$\log J_0 = K_1 - (K_2/T_2) \qquad (1)$$

and

$$\log J = K^1 - (K_2/T) \qquad (2)$$

Subtracting (2) from (1)

$$\log (J_0/J) = K_2 [(1/T) - (1/T_0)] \qquad (3)$$

But J_0/J, the ratio of the energy emitted by any body to the energy emitted by a black body at the same temperature is, by definition, the *emissive power* of the body.

If the emissive power of a black body is taken as unity, then the emissive power is equal to the *absorptive power*. Since most all of the bodies dealt with in pyrometry are opaque,

$a = e = 1 - r.$

Where

a = the absorptive power,

e = the emissive power,

r = the reflective power.

Equation (3) may now be written

$$\frac{1}{T} - \frac{1}{T_0} = \frac{\log a}{K_2} = \frac{\lambda \log a}{14{,}500 \times 0.4343} \qquad (4)$$

The absorptive power varies markedly with the wave-length, but only slightly with temperature. Hence, if the absorptive power, a, is known for any substance at the particular wave-length used, the true temperature, T, may be determined.

Suppose, for example, that an optical pyrometer indicates a temperature of 1300 deg. when sighted upon a stripe of incandescant iron and let us suppose further that the pyrometer utilizes a wave-length of 0.65μ. The absorptive power, a, for iron at 0.65μ is about 0.415. Substituting in equation (4)

$$\frac{1}{T} - \frac{1}{1300 + 273} = \frac{0.65 \log 0.415}{14{,}500 \times 0.4343}$$

whence

$t = 1405$ deg. C.

The following tables, I and II, may be used to determine the true temperature of a body composed of these metals. The tables are made out for a wave-length of 0.65μ. This is approximately the wave-length used by most optical pyrometers.

Table I.

Corrections to be added to pyrometer readings to reduce to true temperatures.

t_0	*Ag.*	*Au.*	*Cu.* (solid)	*Cu.* (liquid)	*Rh.*
600	100	80	70	60	50
700	130	100	90	80	65
800	160	125	115	100	80
900	195	150	140	120	100
1000	235	180	170	140	120
1100	275	210	200	165	140
1200	320	245	235	190	165
1300	370	285	270	215	190
1400	425	325	305	255	215
1500	485	365	345	285	245
1600	550	410	385	320	270
1700	620	460	430	360	300
1800	695	515	480	405	335
1900	775	575	535	450	370
2000	865	635	590	495	405

Table II.

Corrections to be added to pyrometer readings to reduce to true temperatures:

t_0	*Ni.*	*Pt.*	*Fe.*	*W.*	*Ta.*
600	35	35	25	15	15
700	45	45	35	25	20
800	55	55	45	35	30
900	70	70	55	45	40
1000	85	85	65	55	50
1100	100	100	75	65	60
1200	115	115	90	75	70
1300	135	130	105	85	80
1400	155	150	120	95	90
1500	175	170	135	110	100
1600	195	190	150	125	110
1700	215	210	165	140	125

Corrections to be added to pyrometer readings to reduce to true temperatures:

t_0	*Ni.*	*Pt.*	*Fe.*	*W.*	*Ta.*
1800	240	235	180	155	140
1900	265	260	200	170	155
2000	290	285	220	185	170

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The FitzGerald and Bennie Laboratories in Niagara Falls

In the following article an attempt will be made to give some notion of the work of the FitzGerald and Bennie Laboratories, at Niagara Falls, as they should be a matter of general interest on account of their somewhat unique nature. However, some of the most interesting work cannot be described on account of its confidential nature.

The plan of organizing such laboratories occurred to the founders while they were working for the Carborundum Company and the Acheson Graphite Company, because it seemed that not only these companies, but many others, had all sorts of problems which for their solution needed merely some systematic work in the laboratory. No doubt some large manufacturers would have a research laboratory of their own, and might not require outside assistance, but many people engaged in engineering and manufacturing work would not have enough research work to keep a laboratory of their own busy.

As an example of such work people would frequently inquire about methods of melting in electric furnace, so as to form alloys which could not be fused in fuel-fired furnaces, and such has proved to be the case. Problems would also arise in relation to the power developments at Niagara Falls. For example, Mr. FitzGerald made a study of transformer oils and an investigation which showed the error of using iron pipes for

FIG. 1.—CORNER OF FURNACE ROOM.

carrying cooling water used in transformers. Trouble was experienced with marble panels used in high-tension switch boards, which was found to be due to the formation of calcium chloride on the surface. A study of the deterioration of wooden insulator pins showed that this was due probably in part to ozone, and certainly in part to nitric acid formed by electrical discharges.

It did not appear advisable at first to attempt the construction of an elaborate experimental works, because it was uncertain in just what direction work would chiefly develop and, moreover, it seemed probable that much work, at least that proposed on a large scale, would have to be carried on at the plants of clients, or would necessitate the actual building of apparatus and plants specially for carrying on the experimental work. Experience has shown that this judgment was correct, for while a research laboratory of this kind may well be equipped with the necessary apparatus and materials for carrying on preliminary experiments on a small scale, or even in some cases semi-commercially, it is not feasible to attempt work on such a large scale as a commercial undertaking would demand.

An obvious objection to a lack of elaborate experimental facilities was that much work had to be turned away in the case of prospective clients who had no facilities of their own for experimental work, and did not feel inclined to equip their plants with the necessary apparatus. This led to the installation of a laboratory plant where experimental work on electric furnaces could be conducted. A 25-kw transformer which would give secondary emf's of 110 or 55 volts according to the connections was installed. Small as it was this greatly increased the field of the laboratories work.

Several important investigations on electric furnace construction and metallurgical problems of various kinds were carried to a successful conclusion. Hopeless as it might seem with such a small equipment a study of the graphitization of electrodes by the process patented in England in 1893 by Castner was undertaken, and led finally to the development of a com-

Switching Directions For 5-KW Furnace Set

Switch Combination	Secondary Volts	Maximum Current	Maximum KW
1-3-5-8-10-12	40	125	5
1-3-5-8-9-12	20	250	5
1-3-5-7-9-11	10	500	5
2-3-6-7-9-11	5	500	2.5
2-4-6-7-9-11	2.5	500	1.25

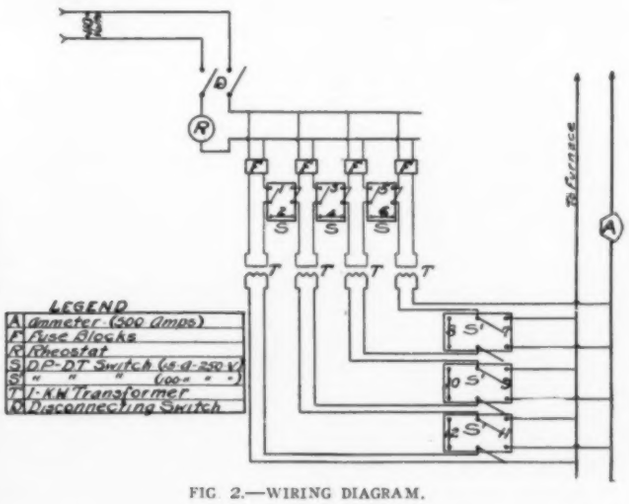


FIG 2.—WIRING DIAGRAM.

mercial furnace for the purpose. Much experimental work was also done on the heat treatment of carbon, the production of carbides of various metals, and several special alloys. A furnace was also developed by data established with this small unit employing combined gas and electric heating. That this combined method is of value is shown by the fact that five such furnaces are now running for heating certain materials, the electrical energy being used to reach the higher temperatures only.

Meanwhile, owing to the liberal policy of local power companies, facilities could be had as to buildings and power permitting work on a much larger scale. For experimental and demonstration purposes a local building was remodeled and equipped with one Kjellin and two Colby induction furnaces. At another location in the vicinity a furnace of the Héroult type was installed in order to study the Lash Process of making steel. For this purpose a 750-kw transformer was installed, as well as a complete crane and ladle equipment, the whole comprising a miniature steel making plant.

An interesting problem undertaken by the laboratories was the development of a furnace for working the Imbert Process.

This process is for the production of zinc from sulphide ores, using iron to combine with the sulphur. Many experiments had been carried on in Europe with this process, but the furnaces had not proved satisfactory.

The problem presented was the construction of a furnace in which it was possible to form a molten bath of iron, and feed into this the zinc ore. It was further required that the furnace should be gas-tight, and that accurate temperature regulation should be possible. In conjunction with Mr. John Thomson a furnace was designed with a capacity of 600 lb. of iron, and

FIG. 3.—DRAFTING ROOM AND LIBRARY.

using 50 kw as the maximum. A place was found at Niagara Falls where this furnace could be built and tested, and experiments made which gave all the necessary data for the design of a 150-kw furnace.

With this latter furnace experimental work in Europe was to be carried on at the works of the Hohenlohehütte, Upper Silesia, and it was thought desirable to ship the whole electrical equipment, as well as the furnace parts, from the United States.

The laboratories then installed the whole electrical equipment in Hohenlohehütte, and during a period of three months operated the electrical plant and the furnaces. From the data obtained as the result of these preliminary experiments a very complete experimental plant was designed which would permit of working on the commercial scale.

Another instance in which the work of the laboratories has been carried into actual commercial practice is shown in the case of the plant designed and operated for some time for the Norton Company, at Chippawa, Ont., where is made the Crystolon (silicon carbide) used by that company as an abrasive. The first unit, consisting of 750 kw electrical output and six furnaces, has since been greatly enlarged. (An illustrated description of this interesting plant, by Mr. FitzGerald, will be found elsewhere in this issue.—Ed.)

The result of several years' experience in work of this kind resulted finally in the present equipment of the laboratories. This apparently was the best design which would at the same time permit of experimental work on a sufficiently large scale to determine whether or not there was a reasonable chance of commercial success in any new process, and to work out details for commercial plants.

The office building has the offices, library, and drafting rooms on the second floor, while the first floor is devoted to a chemical and physical laboratory. The building connects by a covered passage with the furnace room. This is an "L" shaped building, 100 ft. long, 60 ft. wide for rather more than half its length, and 80 ft. wide for the remaining 42 ft. The furnace room is 15 ft. high to the eaves, and the roof has a lantern for its whole length to provide thorough ventilation. One corner is partitioned off for a transformer room.

The electric current is supplied at 2200 volts, and is stepped down by a 150 kva. transformer, which has twenty-two taps in the primary coil, and two secondary coils which can be connected in series or parallel by means of a switch. This arrangement permits of delivering current to the secondary busbars at voltages ranging from 50 to 100 volts in 2.5-volt steps, and from 100 to 200 volts in 5-volt steps.

This apparatus is used for the larger experiments with electric furnaces. For smaller work not requiring more than 4 or 5 kw a simple and convenient equipment is used which may be worth describing. It consists of four 1-kw. transformers, 100 volts primary, 10 volts secondary, connected up as shown in the wiring diagram.

As might be expected there are few permanent furnaces at the laboratory, since on account of the great variety required it is better to build furnaces specially for the purpose. In experimental work the construction of temporary furnaces which lend themselves readily to modifications are desirable. One permanent furnace is a two-electrode arc furnace of the Héroult design, which has been used for a great variety of experiments, making special steels, various alloys, and trying out metallurgical processes.

This furnace is arranged with a readily removable roof, which when in place is less than 2 ft. from the molten bath of metal.

This method provides a severe test for refractory materials, and some interesting work has been done in the development of new refractories, as well as the study of heat insulation.

Another furnace of more or less permanent nature is of the ordinary Siemens type, and is used for testing electrodes in an investigation on methods of manufacture.

A very useful apparatus is the large tube furnace, which can be usefully employed in various ways, but especially in making melting point determinations. The tube is of carbon, and is

FIG. 4.—CHEMICAL LABORATORY.

heated by means of a granular carbon resistor. The inside diameter of the tube is 4 in. A furnace of this kind is also very useful for submitting materials when heated to the action of various gases.

Of importance equal to the equipment is the staff of trained electric furnace workers. Skilled in the construction and operation of all sorts of electric furnaces these men contribute not a little towards the successful conduct of an experiment. Experimental research is essentially costly, but not necessarily expensive. Only highly paid men are worth having in a research laboratory, as efficiency is of prime importance. This has been the policy of the FitzGerald & Bennie Laboratories.

Notes on Electric Zinc Smelting.

By WOOLSEY MCA. JOHNSON.

Electric zinc smelting for some years has been the subject of much criticism both public and private. This criticism has been of all kinds, sincere and insincere, fair and unfair, sensible and senseless, and has come from all sorts and conditions of people. I, myself, have given the subject, I believe, a severe analysis as to its limitations and whatever success I may attain has been due in no small measure to this course of action.

But much of the criticism is due to a general intellectual myopia and a fixed mental astigmatism on the part of the critics. Such has seemed to me to be in the main elementally humorous and to fit precisely some of the categories of the ridiculous found in Henri Bergson's "Le rire."

It is the obviousness of the central conception that causes this attitude on my part. For all that is needed is to compare the action of an electric zinc furnace which smelts continuously in

FIG. 1.—FURNACE BUILDING AND LABORATORY OF THE CONTINUOUS ZINC FURNACE CO. AT HARTFORD, CONN.

a reducing atmosphere, saving by-products and susceptible of expansion to large-sized units, with the operation of the 50-lb. retort where the action is intermittent and as inefficient from modern industry's standpoint as is the feeding of a sick calf with a spoon. Other attempts to solve the zinc problem like wet processes and blast furnace methods have usually seemed of little commercial promise and all have proved abortive.

Now, while the central idea of electric zinc smelting is obvious and simple, its practicalization and its commercialization are neither obvious nor simple. On the other hand, people have erred in magnifying the intrinsically great difficulties to such an extent that these clouds have distorted the view of a real and great mountain. The point of view of such critics is perfectly natural and when rightly interpreted, their criticisms are of great value to the pioneer.

Pressure of work now prevents me from writing at length on either the possibilities and probabilities of our enterprise or giving much data on the Hartford actualities. An article in the METALLURGICAL AND CHEMICAL ENGINEERING for May, 1912 and in *Iron Age* of May 2, 1912, gave some of our experimental facts and an outline of the philosophy of the subject or, we might say with more definite expression, a sketch of its architectonics.

I give merely herewith a short summary of a test that to me is the most interesting test that I have ever made, and a few personal comments.

Metallurgical Balance Sheet of Run 4 E. F. 19.

Ore, 2840 lb. dry at 39.0 per cent	1108	lb. zinc
Flue-dust, 300 lb. dry at 56.7 per cent	170	" "
Total zinc delivered to pre-heater	1278	" "
Zinc in spelter, 691 lb. at 97.1 per cent	670.	lb. zinc
" blue-powder, 32 lb. at 96.0 per cent	30.8	" "
" flue-dust, 280 lb. at 68.6 per cent	192.0	" "
" slag, 1359 lb. at 2.49 per cent	34.0	" "
" charge not smelted and found in furnace, 81 lb. at 50.5 per cent	20.7	" "
Total zinc accounted for	947.5	" "
Unaccounted for, lost in "dusting," in charging pre-heater, and electric furnace, and in soakage of furnace	330.5	lb zinc
	1278.	" "

As on next run, furnace gave a "plus recovery," soakage was largest item.

As good a metallurgical "cut-off" as possible was made. Loss by volatilization was practically nil.

Slag analyzed:

	SiO_2	FeO	Zn	ZnO
	per cent	per cent	per cent	per cent
No. 1	39.2	15.5	1.90	2.38
No. 2	39.0	14.3	2.04	2.51
No. 3	32.2	23.3	2.50	3.13
No. 4	27.5	27.0	3.50	4.31

Slags contained less than 0.05 per cent Pb, 0.05 per cent Cu. The ore analyzed approximately, 39.0 per cent Zu, 8.7 Pb.

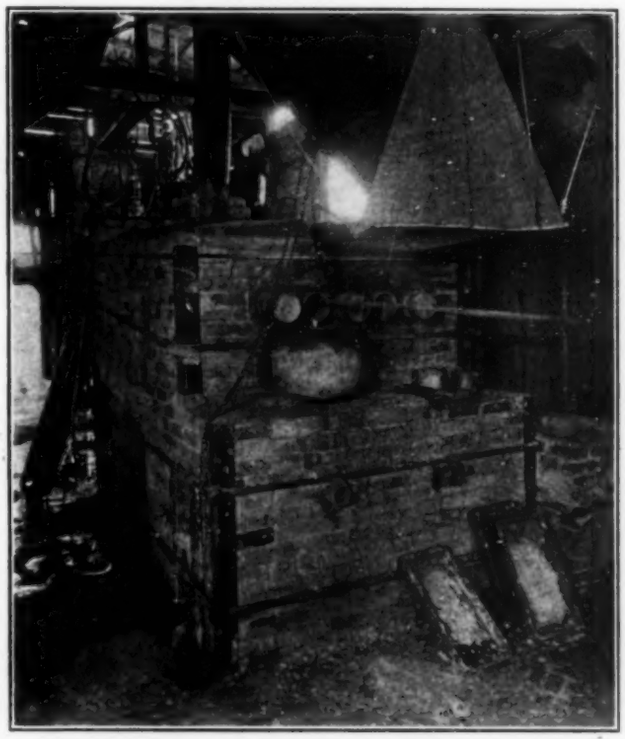


FIG. 2.—TAPPING ELECTROTHERMIC ZINC.

12.0 Fe, 5.2 CaO, 1.0 MgO, 8.0 SiO_2, 3.0 Na_2O and K_2O, 0.59 Cu, 3.70 S.

Most of analyses were made in duplicate and by two different chemists:

Time of smelting		48 hr.
Kilowatt-hours on phase A		1754
" " B		586
Both		2340
	Phase A.	Phase B.
Av. volts	41.3	19.9
Av. amp.	1200.	440.
Av. kilowatts	36.	12.2

Av. power on both phases 48.8 kilowatt.

$$\text{Kilowatt-hours per lb. spelter} \frac{2340}{691} = 3.39$$

$$\text{Kilowatt-hours per ton pay charge} \frac{2340}{3140} \times 2000 = 1490.$$

Lead and matte were not tapped out. I have made runs giving much better results than this, but this run is different in that we then operated on conditions to make a new slag high in FeO and relatively low in silica.

The slags are higher in FeO and lower in ZnO than any I have ever made either in a smelting furnace or in a research furnace.

It would appear that this test has little or no metallurgical

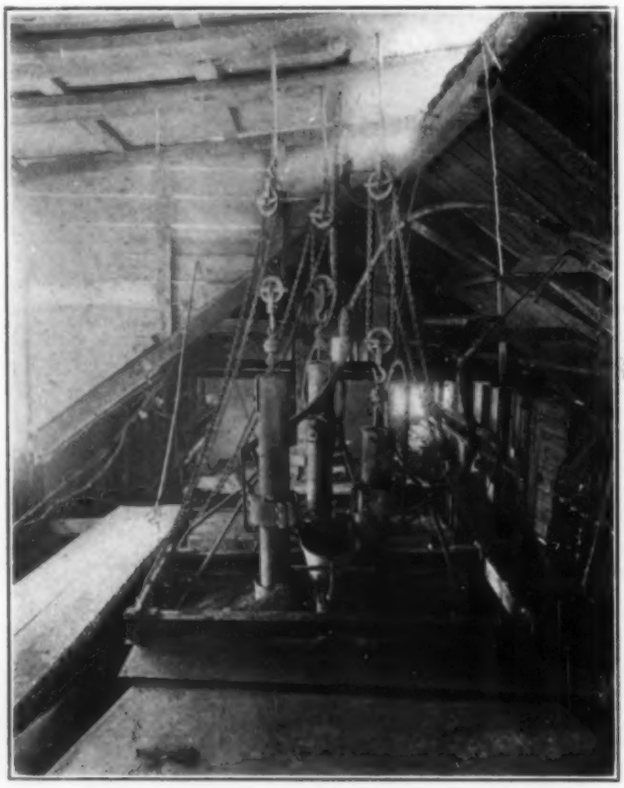


FIG. 3.—ELECTRIC ZINC FURNACE FROM CHARGING FLOOR.

promise. For considered from the standpoint of productive results, it is the poorest long test that has ever been made at Hartford in a twelvemonth. We have made runs making considerably less flue-dust and blue-powder with slags lower in zinc and having a lower power consumption per ton charge smelter and per lb. spelter made. Its results are not decisive.

But looking at things in a broad way, this run with its slags high in iron oxide and comparatively low in zinc oxide shows "what a wonderful metallurgical agent is the electric current, when its use is understood." It was in the year 1905 that I conducted some experiments on the relative reducibility by coke of iron oxide and zinc oxide dissolved in slag, at temperatures from 1100 deg. C. to 1300 deg. C. The purpose of these were to find upper limits in FeO possible with a slag low enough in ZnO to be commercial, and they were predicative of our present successes.

It was found that the affinities—to use a good old-fashioned term of chemistry—between the carbon, oxygen, iron and zinc molecules and atoms change with the conditions much in the same manner that the affinities between iron, C, Si and O change in the blowing of a Bessemer converter with varying physico-chemical conditions.

Since that time these tests which were the precursors of our present achievements have been studied in the course of all our work both in the light of metallurgical and commercial probabilities and also in the light of the phase-rule.

As the successful electric zinc furnace will create a new metallurgy as distinct from the present metallurgy as that of the Bessemer converter is from the metallurgy of a puddling furnace, it is hoped that this test will prove of some technical interest to metallurgists. I therefore take pleasure in publishing an account of it in the columns of METALLURGICAL AND CHEMICAL ENGINEERING—a journal that expounds the modern principles of physical chemistry and commercial science to a profession that is absorbing them quickly and gladly.

It is a peculiar fact that most of the zinc made in this country has come "from Missouri." The photographs of our Yankee zinc furnace reproduced with this article will "show" some people a few things. At least it would seem probable that they

FIG. 4.—CASTING ELECTRIC FINE SPELTER.

will be "shown." At any rate, it is necessary "to show them."

Hartford, Conn.

Mechanical Agitators.

In designing the details for *mechanical agitators*, sufficient provision generally is not made for break-downs and replacements. Attention to the following points will be appreciated during working by the engineer in charge:

(1) The pinion wheel on the line shaft should be made "split."

(2) The same applies also to the bevelled crown wheel on the vertical agitator shaft.

(3) The vertical agitator shaft can be arranged, either by coupling or other means, so that the step-bearing on the tank bottom can be entirely removed without removing the crown wheel above it, and without having to take out a length of the line shaft.

(4) In order to have all the pinion wheels on the line shaft interchangeable, in many cases it will be found a subsequent economy to keep the line shafting the same size for its whole length, and not, as is usual, to decrease the diameter of the line shaft as one gets farther away from the driven end.

In smelting gold slimes with an oxidizing flux, if the oxidizing agent be manganese dioxide and used in excess, the slag produced may carry an excessive quantity of gold which does not show in the "pan."

GUIDE AND GRIPPER.

The Use of Electric Furnace Pig Iron in the Open Hearth Furnace.

By D. A. Lyon.

In a paper recently presented by Prof. Richards at a meeting of the Engineers' Society of Western Pennsylvania (an abstract of which appeared in the July number of this Journal, page 397), he pointed out the fact that a metal may be obtained from the electric reduction furnace which is much better suited to steel making than is the product of the blast furnace. In this connection it may be interesting to note that the advantages gained in the use of this metal were not at first appreciated by the Swedish steel makers.

The first metal produced at Trollhättan did not look very much like pig iron and moreover, as its analysis was different from that of the metal which they had been using, they were doubtful as to being able to use it in the production of steel, and even hesitated about attempting to do so.

The first attempt at using this iron in the production of steel was made at Degerfors. A basic furnace was used. The iron of the electric furnace was mixed with ordinary gray iron and a smaller quantity of scrap than usual. This mixture was made so as to insure a hot metal upon melting down. The results exceeded their expectations, and on the third trial the charge was made up only of the electric furnace metal and scrap. Much to the surprise of those operating the furnace, it was observed that the usual boil did not occur immediately after the metal was melted.

Tests were then made on the electric furnace metal in an acid furnace. Although small quantities of this metal were at first used, it was soon ascertained that the charge could be made up of the ordinary proportions of 64 per cent pig iron and 36 per cent scrap.

Pig iron of normal composition was finally obtained as a product of the Trollhättan furnace, and when this iron was used for steel melting in the open-hearth, together with the same proportion of scrap as had been used in the previous tests, it was found that a longer time was required in which to complete the refining of the metal, and that it was necessary to add more ore than in the previous tests.

As a result of the tests at Degerfors the conclusion was reached that a metal could be produced in the electric reduction furnace which was more suitable for steel making than the ordinary pig iron which had previously been used for this purpose.

In order to understand the reason for this conclusion, it may be well to note briefly some of the reactions which take place in the open-hearth when treating pig iron of normal composition as compared to those which take place when treating pig steel.

In converting normal pig iron into steel in the open-hearth process, in order to meet the requirements of the process, the pig iron must contain enough Si to protect the iron from oxidation during the melting down, and likewise enough Si and Mn to free the iron after melting down from whatever oxides and gases that were formed and taken up during the production of the pig iron in the blast furnace, as a result of the action of the blast. Whatever Si and Mn that may be present in excess of this amount only prolongs the time required to finish the heat.

Immediately after, and even during the melting, there occurs a violent boiling of the metal. This is especially so in an acid furnace if a low silicon iron is used, even if it is not spongy. Again, there is a similar partial boil when the metal is charged into the ladle and moulds, especially in the case of hard steel. On the other hand when electric furnace "pig steel" is heated in the open-hearth furnace process this partial boil does not take place, and the regular boil commences immediately after the charge is melted and before the ore is added.

Several theories have been advanced to account for the behavior in this manner of "pig steel" upon melting. One of these is that the material is practically free from minute particles of oxides such as are generally present in ordinary pig iron, and which, as previously stated, are produced by the re-oxidizing effect of the blast. Due to the absence of these oxides, practically no reaction with the Si and Mn present occurs at this time, and on this account the partial boil in the open-hearth furnace, during and after the melting, when treating electric furnace metal, does not occur, and it is possible to at once decarburize the charge by ore additions. The presence of silicon in such pig iron is therefore unnecessary during the first portion of the open-hearth process.

As above stated, in the tests at Degerfors it was found that more time and more ore was required in the treatment of normal electric furnace pig iron than was the case in the treatment of normal blast furnace pig iron. The reason for this is no doubt due to the fact that inasmuch as pig iron of normal composition contains no oxides it is not necessary that silicon and manganese be present in the iron in order to take up oxides, and hence the removal of the Si must be accomplished principally by means of ore, and as pointed out by Odelberg, only after this is accomplished can the decarburizing proper commence.

Summarized then, we may say:

1. That "pig steel" made in the electric furnace is better suited to the production of open-hearth steel than is the normal blast furnace pig iron.

2. That normal pig iron made in the electric furnace is less suited to the production of open-hearth steel than is normal blast furnace pig iron.

From what has been stated above it must not be inferred that it is not possible to produce normal pig iron in the electric furnace. As a matter of fact some hundreds of tons have been so produced in this country and in Sweden. Although the furnace at Trollhättan is so operated as to produce "pig steel," because this metal is better suited to steel making than is normal pig iron, the Noble Electric Steel Company, of California, on the other hand so operate their furnaces as to produce a soft foundry iron which is particularly suited to meet the requirements of the foundries of that section of the country. However, it has been found that a greater output may be obtained when making "pig steel" per unit of electrical energy expended than is the case when foundry pig iron is produced.

That the production of "pig steel" has met the requirements of the Swedish and Norwegian steel makers is borne out by the fact that as a result of the successful operation of the furnace at Trollhättan, and of the tests at Degerfors, the following plants have been built and are now in operation.

Place	No. of furnaces.	Rated H.P. capacity.
Domnarfvet, Sweden	1	3000
Hardanger, Norway	1	3000
Hagfors, Sweden	2	3000
The following are approaching completion:		
Hardanger, Norway	1	3000
Arendal, Norway	3	3000
Switzerland	1	2500

The Uddleholms Company are also increasing their plant at Hagfors by a third furnace, and are installing three more furnaces at their Nykroppa works. Altogether they propose to spend about $1,700,000 on these plants, and it is stated that they will probably substitute electric smelting altogether for their blast furnaces.

Pittsburgh, Pa.

Iron and Steel Institute.—The autumn meeting of the British Iron and Steel Institute will be held at Leeds from September 30th to October 4th. The professional sessions will be held at the Hall of the Philosophical and Literary Society. There will be a reception by the Lord Mayor and a garden party tendered to Lord and Lady Airedale, besides excursions to works in the neighborhood.

GUIDE AND GRIPPER.

The Disadvantages of the New American Standard Copper Specifications.

By Ernest A. Lewis.

In June, 1911, the American Society for Testing Materials issued a proposed standard specification for copper, which, although it has met with approval by many American users and manufacturers of copper, is most unsatisfactory compared with the high-class copper which English users and makers approve. I am quite at a loss to understand why such a specification has been adopted.

America supplies the world with the largest proportion of copper of any country manufacturing this metal. The cause of the unsatisfactory nature of the new standard specification is most probably the development of the process of manufacturing modern copper. This is the adoption of electrolytic methods in conjunction with the Bessemerizing of crude mattes to 99 per cent purity and upwards, and no impurity worth mentioning, which copper is still further refined by electrolysis and the remaining small impurity is eliminated. It is then melted down into billets, wire bars and so forth.

It is most excellent copper, as a rule, for high conductivity wire and brass alloys, but for wearing properties it is inferior. I believe it is safe to say that the old Welch process of smelting is practically obsolete nowadays. The modern cupola and Bessemerizing plant has eliminated it; even in smelters where the old "Tough" and "Best Select" copper is made, the process is so altered as hardly to be recognized as the old Welch process of fifty years ago. The advance of the electrolytic refineries has altered the character of the copper, both in its properties for manufacture and wear.

To advocate the use and adoption of exceedingly pure electrolytic copper in preference to tough arsenical copper is similar to advocating the use of wrought iron for chisels and knives and the disuse of steel. What would be said of any committee which suggested such a thing? Wrought iron has its uses, so has steel. Pure copper has its uses, so has tough copper.

It is well known that all metals have definite properties, and that the presence or absence of certain elements in them makes a great difference in these properties. The most characteristic of metals to which an added element makes an enormous difference is iron when carbon is added. Take the comparatively pure metal iron as wrought iron, add to it by well-known methods 0.2 per cent carbon, 0.5 per cent carbon and 1.0 per cent carbon. We have practically four different metals or alloys of iron and carbon. There is a vast difference in their properties; each is suitable for different purposes. If the iron-carbon alloy is complicated by the addition of a few percentages of chromium or manganese we have alloys of totally different properties to the original iron.

When a small percentage of one metal is added to another it may mix with it and not alloy, the perfection of mixing depending on the rapidity of cooling, an example being bismuth in very pure copper, free from oxygen and arsenic; it may dissolve entirely in the metal like zinc will dissolve in copper; it may unite with a portion of the metal to which it is added, and on cooling separate out as a net work, such as arsenic in copper or phosphorus in copper; it may form a definite crystalline composed with a portion of the metal embedded in the alloy like cubes of Sb SN in an alloy of 10 per cent antimony and 90 per cent tin. All those various types of alloy have their uses.

Of recent years a large amount of research has been done in determining the properties of copper of various kinds. The Alloys Research Committee of the (British) Institution of Mechanical Engineers published in 1893 a valuable research by the late Professor Roberts-Austen and at the same time a valuable paper was read before the same body on "tensile" tests and a chemical analysis of copper plates from fireboxes of locomotives on the Great Western Railway by Mr. William Dean. These two papers and their discussions contain an enormous amount of valuable information. Professor Roberts-Austen's research was hardly on commercial lines, but it helps to explain many things connected with the practical metallurgy of copper. In 1903 the writer publisher a research on the effect of impurities on deoxidized commercial copper (*Engineering*, Dec. 4, 1903) and another research on "The effect of silver, bismuth and aluminium upon the mechanical properties of 'Tough Pitch' copper containing arsenic," by F. Johnson, M. Sc., was read before the Institute of Metals in September, 1910.

In the face of such papers it is difficult to understand why any committee representing makers and users of copper should recommend for all purposes a copper of 99.88 per cent purity. One of the most important uses of copper in every country, except the United States of America, is for fireboxes and tubes in locomotives. A copper which will stand this work will stand anything.

The various researches on copper have now brought forward an explanation of the properties of different varieties of the metal. It must be remembered that there is nearly as big a difference between the properties of a pure copper such as the committee recommended and a good quality of arsenical copper as there is between wrought iron and rail steel.

One thing the committee overlooked is that *it is impossible to work pure copper*. The copper they recommended is non-arsenical oxygen copper with only sufficient oxygen in it to enable it to be rolled hot, but such a copper is too soft to be of commercial value from a coppersmith's point of view. If such copper was subjected to a process for hardening it, such as the addition of phosphorus and removal of oxygen, it would pass the chemical test all right, but would fail on the electrical test.

From what I can gather from American friends the electrical test is considered of great importance in America. For electrical work this test is considered of great importance over there. For electrical work this test is, of course, important, but for copper for sheets, tubes and rods, and ingots for casting into brass for rolling, *in my opinion it is valueless and even misleading*. What is wanted is bending tests, opening tests, swaying tests, tensile tests, chemical analyses of value, *i. e.*, limiting the impurities. None of these appears in the American specification.

The metals and non-metals which may be present in refined copper or manufactured copper either as impurities or intentionally added for some purpose are lead, bismuth, tin, antimony, arsenic, zinc, manganese, nickel, phosphorus, silicon, and oxygen. Taking commercial brands of copper ingot the only brands which do not contain any of the above constituents other than in traces, except oxygen, are the various remelted electrolytic brands and native copper. These are the only brands which would pass the American specification.

If we take the metals and non-metals in order and compare their properties and effect on copper, as shown by modern research, with the opinions of experts in the manufacture and use of copper, we see the great mistake the American committee has made.

Lead.—In pure copper cast under ideal conditions with every care taken *to keep out oxygen*, this metal makes copper unworkable even in so minute a quantity as 0.1 per cent. In the Welch process of refining copper, lead is added to help to oxidize other impurities, but it must be removed from copper for sheets. For casting copper for the foundry it is immaterial if 0.1 per cent lead is left in. In an arsenical copper 0.1 per cent lead is harmless in the presence of 0.3 per cent arsenic and upwards, as will be shown below.

Bismuth.—This metal need hardly be considered in the large amounts that lead is met with, but in minute quantity it can be present in electrolytic copper. It has been proved that 0.005 per cent will make a pure copper made from electrolytic cathodes of inferior working qualities if the right adjustment

of oxygen is not correct. This condition might easily be obtained with a copper which would pass the American specifications as regards both analysis and conductivity, but such copper would be rejected by a bending test, such as is required in England. The American committee who drew up the specifications was, I understand, composed of representatives of users and makers. I do not suppose for one moment that anyone would make such a copper as I have described intentionally, as makers have a reputation to live up to. I merely mention it to show how a specification of this kind requires the greatest care in drawing up. Consider what would happen if owing to a quantity of bismuthic copper ore getting to the maker's smelter, unnoticed probably by their chemists. When the copper comes to the users it will not work hot. It is sampled as suggested, passes the analysis test and the conduc- of 0.05 per cent; this is at least five times the amount present had passed the specifications. Probably we should see a new standard specification drawn up on the lines I am suggesting. It has been proved conclusively that arsenic will neutralize the injurious properties of bismuth even when present in quantity of 0.05 per cent; this is at least five times the amount present in any commercial copper.

Tin is not present in commercial refined copper, but it has been added to copper for tubes to harden them in quantity up to 1 per cent. As far as I am aware this copper is not used now.

Antimony is not present in commercial copper except in traces, but it toughens copper and increases the tensile strength. Although it is not made commercially, I am inclined to think there is a future for this kind of copper when the right proportions of oxygen and antimony are known. It is much harder than even arsenical copper and would probably resist erosion well.

Arsenic is usually present in the English variety of copper known as "tough" copper. It is extremely beneficial in copper for coppersmith's work owing to its remarkable properties, which are dealt with below.

Zinc is never present in refined coppers, but for copper for drawing into tubes for plumbers' work and such like made by casting round sand cores and drawing direct into tubes, 1 per cent is sometimes added to non-arsenical copper to enable sound castings to be made. It is not present in any other kind of copper.

Manganese is never present in refined copper, but it has been used and recommended for use similar to zinc.

Nickel is sometimes present in refined copper; it intensifies the injurious effect of bismuth and lead. In England 1 per cent or 2 per cent nickel has been added to copper for use as loco tubes and stays.

Phosphorus is not present in refinery copper, but when casting oxygen-free copper 0.06 per cent is present, as a rule, in the finished metal. This kind of copper cast from pure electrolytic is very good quality. It can be rolled hot at a dull red heat and drawn down. It is altogether debarred from use in America if the standard specifications are acted upon.

Silicon is not present in refined copper, but for electrolytic castings the only way to make them is to add 2 per cent cuprosilicon to the molten copper (made from cathodes) before casting. This does not come under the specifications.

Oxygen is the most important element in copper. It is present in all copper. Even copper containing phosphorus contains 0.02 per cent to 0.03 per cent. In other kinds of copper *its quantity is of importance*, but the amount to be present is not even mentioned in the standard specifications.

The only metals or non-metals which interest copper refiners are lead, bismuth, arsenic, oxygen, and sometimes nickel. These elements may be grouped into three groups:

1. Lead and bismuth.
2. Arsenic and oxygen.
3. Nickel.

The first group are the elements which in pure copper, free from arsenic and oxygen, render copper brittle and weaken the tensile strength, especially above the ordinary temperature. Roberts-Austen took a very pure copper and added to it 0.1 per cent bismuth, it was cast under conditions which precluded any chance of oxygen being present, and then he tested the rods as cast. The following were his results: (See *Proceedings* of the Institution of Mechanical Engineers, April, 1893, second report to the Alloys Research Committee.)

Temperature of rod.	Tensile strength per square inch.	Percentage of elongation.
15 deg. C.	18,020 lb.	20 per cent.
101 deg. C.	11,510 lb.	15 per cent.
162 deg. C.	5,620 lb.	0.0 per cent.
199 deg. C.	3,860 lb.	0.0 per cent.
274 deg. C.	4,940 lb.	0.0 per cent.
292 deg. C.	2,770 lb.	0.5 per cent.

It would be quite impossible to work this copper hot or even cold. Under conditions similar to these tests I have proved that 0.005 per cent bismuth would render copper unworkable. I have also found out experimentally that similar quantities of lead *in the complete absence of oxygen or arsenic* will make copper unworkable hot. A microscopical examination of the structure shows clearly why it will not work. Neither lead nor bismuth will alloy with copper when oxygen or arsenic are not present in certain definite quantities.

Both lead and bismuth are easily fusible metals; they surround the crystals of copper as a minute network of lead or bismuth. When they are heated they melt and the copper loses all cohesion, hence the rapid fall in tensile strength and elongation at high temperatures. Even in the cold bismuth renders copper unworkable even in minute quantity, but lead being of a plastic nature does not affect the copper in the cold.

The second group are the elements which not only toughen copper, but also render inert the ill effect of the metals bismuth and lead. *It is an impossibility for any refinery to supply billets for rolling purposes which do not contain one or other of the elements in quantity sufficient to effect working properties.* Roberts-Austen in his classical research took several percentages of arsenic and added to it pure copper under the same conditions as the bismuth tests described above and the following results are taken from his tests:

Temperature of rod.	Tensile strength per square inch.	Elongation per cent.
COPPER CONTAINING 1.5 PER CENT ARSENIC (AS CAST).		
15 deg. C.	26,460 lb.	20.0 per cent.
215 deg. C.	19,450 lb.	37.0 per cent.
COPPER CONTAINING 1.2 PER CENT ARSENIC (AS CAST).		
20 deg. C.	24,840 lb.	20.0 per cent.
224 deg. C.	16,460 lb.	15.0 per cent.
346 deg. C.	14,860 lb.	10.0 per cent.
COPPER CONTAINING 0.5 PER CENT ARSENIC (WORKED AND ANNEALED).		
18 deg. C.	33,420 lb.	37.0 per cent.
258 deg. C.	30,030 lb.	23.0 per cent.
446 deg. C.	20,000 lb.	13.0 per cent.
COPPER CONTAINING 0.2 PER CENT ARSENIC (WORKED AND ANNEALED.)		
18 deg. C.	30,150 lb.	30.0 per cent.
144 deg. C.	30,960 lb.	21.0 per cent.
249 deg. C.	28,730 lb.	30.0 per cent.

When arsenical copper is examined microscopically the copper crystals are seen to be surrounded with a thick network of alloy which is probably a solution of arsenide of copper in copper. This has the remarkable effect of neutralizing the injurious effect of bismuth and lead. This is well known to English refiners.

In 1903 the writer made some experiments on the effect of bismuth and arsenic on copper containing no oxygen. He found that 0.1 per cent bismuth in pure copper would not roll or bend, but when 0.6 per cent arsenic was added to the same copper it would roll fairly well and also bend. The author also

found that copper containing 0.05 per cent bismuth and 0.6 per cent arsenic would roll and bend well. Such copper without the arsenic would not roll at all.

All refined copper, whether arsenical or non-arsenical, must of necessity contain oxygen when cast from a refinery furnace as distinct from a crucible. F. Johnson in the course of his paper read before the Institute of Metals (September, 1910) shows conclusively that oxygen removes the injurious effect of bismuth. He rolled copper containing 0.052 per cent bismuth and 0.079 per cent oxygen, 0.094 per cent bismuth and 0.155 per cent oxygen and 0.124 per cent bismuth and 0.073 per cent oxygen. He remarks that the last bar "showed a bad surface appearance after the hot-rolling process, but the rolled material could then be hammered out at a red heat to a knife edge without showing any signs of cracking."

It is suggested that bismuth forms an oxide united with a portion of the cuprous oxide, which is malleable. This may be so. Of course, copper with such a high percentage of bismuth could not be rolled on a manufacturing scale, but the results are interesting as showing how the injurious effect of bismuth can be counteracted with oxygen alone without arsenic.

In the same paper F. Johnson gives other results on arsenical copper of the type cast from the refinery furnace. This copper always contains oxygen in addition to arsenic. A certain proportion of oxygen is as necessary in this class of copper as in ordinary refined copper without arsenic. There is really no need for a specification of arsenical copper made from the refinery to specify the percentage of oxygen as unless the proper portion is present the metal would not pass the refiner's tests to which he subjects his metal before ladling. The following are typical results obtained by Johnson:

Mark.	Copper per cent.	Arsenic per cent.	Oxygen per cent.	Tensile strength tons per sq. inch.	Elongation per cent on 3 in.
R	99.905	nil	0.089	14.92	39 per cent.
E	99.592	0.344	0.066	15.70	41 per cent.
EE	99.565	0.410	0.060	15.75	51 per cent.
V¹	99.570	0.361	0.052	15.75	38 per cent.

It will be noticed that R is the only sample which would pass the standard specification of the American Society for Testing Materials. The superiority of the arsenical copper is marked especially in the tensile strength. Further results are given of the effect of arsenic, oxygen, and bismuth in the same paper. I will quote two results:

Arsenic per cent.	Oxygen per cent.	Bismuth per cent.	Tensile strength tons per sq. in.	Elongation per cent on 3 in.
0.420	0.055	0.051	15.71	44
0.390	0.084	0.097	16.09	48

The superiority of the arsenical copper is marked even in the presence of bismuth in quantities which would never be found in practical work. In the paper of Mr. William Dean read at the same meeting of the Institution of Mechanical Engineers at which Professor Roberts-Austen's second report was presented are several examples of the superiority of arsenical copper in practical work on locomotives over non-arsenical copper. Here follows a few results of copper fireboxes:

Mileage.	Arsenic per cent	Lead per cent.	Copper per cent.
489,334	0.534	0.051	99.195
493,994	0.811	0.081	98.901
506,341	0.292	0.126	99.250
177,633	0.013	0.043	99.828
54,564	0.042	0.056	99.810

These are figures of actual working practice and are confirmed by many other large railways. The most significant figures are that the percentages of copper nearest to the American specification are the most unsatisfactory from a user's point of view.

The ratio of arsenic to lead is important in refined copper. There must be three times the quantity of arsenic present as there is lead to get a good copper. The English practice of copper refining gives far better results from a user's point of view than the American.

Having now brought forward indisputable evidence from practical men as to the utter unsuitability of such a standard specification for copper for all purposes, I will compare the American specifications with the English practice. The American specification lays great stress on the electrical conductivity test.

"All wire bars shall have a conductivity of at least 98.5 per cent (annealed) and all ingots and ingot bars shall have a conductivity of at least 97.5 per cent (annealed) excepting only arsenical copper, which shall have a conductivity of not less than 90 per cent (annealed)." It is certainly necessary to have a conductivity test for copper for electrical purposes. But for other purposes it is not only useless, but very misleading.

Of what use is an electrical conductivity test of any kind in arsenical copper? What use is such a test for billets for tubes or cakes for rolling into sheet? It would be possible, as I have shown above, to produce a copper which will pass the conductivity test but would not be satisfactory in working.

Again the standard specification says that the copper contents must be at least 99.880 per cent and to see that the parcel is of this quality it is proposed to take two pieces (probably four pieces are intended, but even this number is quite inadequate) and drill them and from the mixed drillings of these pieces the whole parcel is to be rejected or accepted in case of any dispute.

How any committee representing makers and users could suggest such a test is what I cannot understand. In the first place, even if one got a representative sample in this way, the three different analysts may not agree within 0.03 per cent, and I venture to say that if any one took an ingot of copper and drilled it in several places and mixed the drilling and sent it, as three different samples to the same analyst, even a man of high repute, his results would vary by 0.03 per cent. Another matter is that, as the author pointed out in *Metal Industry* for September, 1911, it is easy for ingots cast at the beginning of a furnace charge to vary by 0.05 per cent from those cast at the end of the ladling.

The very best recast electrolytic copper would only just pass the analytical test of 99.880 per cent purity. As it is absolutely impossible for any refiner to make such recast copper without adding to it 0.08 per cent to 0.1 per cent oxygen as cuprous oxide, it would be impossible to cast the copper as "tough pitch" without the oxygen. It would be highly improbable for such copper to contain lead owing to the property which lead has, that in an acid sulphate solution it separates out as oxide on the anode.

But this does not apply to bismuth, and as the tendency of refiners will be to get over-poled rather than "tough pitch" copper in order to pass the analytical test, bismuth might be present in such copper in minute quantity in such a form as to render it unsuitable for making brass alloys for rolling, etc. Why is not the percentage of bismuth limited to 0.005 per cent, and why is not the proportion of oxygen specified?

Putting on one side the fact that such copper would be too soft in practice for hard wear, it could not be cast from a refinery without oxygen. It is possible to cast billets from crucibles for rolling into tubes with only 0.03 per cent oxygen, by the addition of 0.05 per cent to 0.09 per cent phosphorus, but this variety of copper would not pass the conductivity test, although such copper is excellent from the point of view of hard wear and tear. This is an example of an excellent variety of copper which would pass one test in the specification and fail in another.

The only specification given for the arsenical copper is the unnecessary conductivity test. In England the percentage of arsenic is usually specified to be from 0.35 per cent to 0.6 per cent. Many users have found it necessary to limit the lead to

0.1 per cent. In many cases it is essential to have at least double the quantity of arsenic as there is lead.

In the discussion on the second report to the Alloys Research Committee the following interesting figures were given by one of the speakers, Dr. David Watson. The figures are obtained on copper locomotive fireboxes.

Three good plates.

Lead, per cent.	Arsenic, per cent.
0.079	0.847
0.025	0.440
0.136	0.332

Eight bad plates.

0.322	0.192
0.226	0.142
0.124	0.049
0.384	0.065
0.194	0.047
0.214	0.046
0.164	0.053
0.215	0.047

These figures are typical of the experience of English users and makers of arsenical copper.

Another use of arsenical tough copper is that in the brass foundry it is altogether superior to pure copper for making gun metal and alloys of that type. The arsenic acts as a toughener. In some of the largest brass foundries in England arsenical copper is always used for gun metal.

The American standard specifications are in urgent need of revision for the following reasons:

1. They do not represent the modern views of metallurgists as shown by recent researches and are not drawn up in accordance with known facts published by practical users and makers of copper.

2. They put makers of "tough" copper at a great disadvantage, although modern research shows that "tough" arsenical copper is more suitable for making into tubes, rods, and plates (other than electrical work) than the copper recommended.

3. The methods of rejection or acceptance of parcels of copper by the method of sampling an analysis as described by the specification are unfair to the maker and are against the experience of practical refiners and chemists.

4. The physical tests are quite inadequate as they contain no reference to tensile strength, elongation or bending tests.

5. Chemical tests are of no value unless the various impurities likely to be in copper are specified and limited.

6. Copper which is suitable for one purpose may be quite unsuitable for another purpose, therefore no one specification can cover copper for all purposes.

Birmingham, England.

Tanks and Pipe is the title of Catalog 10, just issued by the Pacific Tank & Pipe Company, of San Francisco, giving an illustrated description and list of sizes of the principal types of tanks built by this company. An interesting type is their patent non-shrinking water tank which is made with a deep channel or groove in the top of the staves. This groove is filled with water from pump discharge which, by absorption, passes into the pores of the wood, keeping the entire tank moist at all times and preventing shrinkage. A similar but modified principle is used in the same company's non-shrinking oil tanks. Other types, described in the catalog, are plain water and oil tanks, closed-top oil tanks, wagon tanks, fermenting tanks, wine storage tanks, brewery tanks, silos, tank towers, wooden pipe, and accessories.

Mr. William B. Ruggles, president of the Ruggles-Coles Engineering Co., 50 Church St., New York City, has just returned from England and advises that the Electro-Metals Co., Ltd., London, have been appointed their sole agents for all Europe, excepting Norway and Sweden. The Electro-Metals Co., Ltd., will appoint sub-agents on the continent.

Experiments in Oil-Smelting in British Columbia

The annual report of the Minister of Mines of British Columbia for 1911 contains some notes by Wm. Fleet Robertson, Provincial Mineralogist on attempts to smelt with oil as fuel. For the past two years the Dominion Oil Smelting Company, Ltd., in Vancouver, has been conducting a series of experiments in the old Van Anda smelter, in an attempt to perfect or render practicable an oil-fired furnace for smelting ores, and has achieved a degree of success such as to render the process worthy of serious consideration. The particular form of furnace being experimented with is covered by Canadian patents granted to J. J. Anderson, and acquired by the company. More recently, March, 1912, Mr. Anderson has taken out United States patents for a new furnace, which is a modification of the Van Anda furnace, designed along lines suggested by Mr. Thomas Kiddie after the latter had made a test at the Van Anda plant.

The Van Anda furnace, of which a rough sketch is given in Fig. 1, is essentially a shaft furnace superimposed above one end of a reverberatory furnace or combustion chamber. In operation, the ore with suitable fluxes is fed into the shaft from the charging floor, passing down onto one end of the reverberatory hearth. The shaft thus serves as a feeding hopper for the reverberatory. The latter is fired from four injectors which squirt vaporized oil into the front of the chamber, the flame impinging on the foot of the ore column in the shaft. The products of combustion pass upward through the charge, thereby heating it to near the melting point, and escape through a suitable flue and stack. The melted ore flows down over the inclined hearth of the reverberatory into a well or sump, in which the matte and slag separate by gravity, each being tapped through holes placed at suitable levels. The injectors are operated under steam pressure, and the proper amount of air is supplied by a pressure blower.

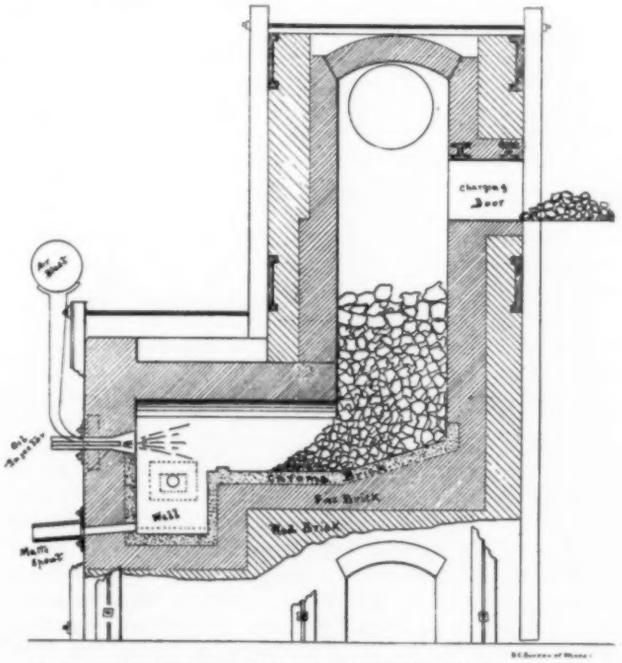


FIG. 1.—DOMINION OIL SMELTING COMPANY. OIL-FIRED BLAST-FURNACE, VAN ANDA, B. C.

The furnace undoubtedly requires and will receive considerable modification before it is commercially successful; but that a considerable advance has been made toward that goal is indicated by the results of a test made by Mr. Thomas Kiddie, a metallurgist of British Columbia, who has had previous experience with oil-fired furnaces at the works of the Orford Copper Company, New Jersey.

The ore mixture smelted consisted of ore from the Boundary district, British Columbia, iron ore as flux, and copper slag from a previous operation. Two burners were started to heat the furnace, when the other two were added. The mixture was readily smelted without trouble or interruption. Allowing one hour for heating the furnace, the oil consumption was as follows: for preliminary heating, 60 gal.; smelting for 2.33 hr., 157 gal., or a total of 217 gal. This gives 14.6 gal. of oil per ton of material smelted, equivalent to a cost of 43.8 cents per ton of ore. The rate of smelting was 110 tons per 24 hours, an increase of over 100 per cent over the best preious demonstration. It was Mr. Kiddie's conclusion that the furnace could be improved to take advantage of more complete combustion of the oil, and the cost of smelting reduced to from 30 to 35 cents per ton of ore. He estimated the saving in labor cost at the furnace at 9 cents per ton of ore.

After the furnace had been remodeled according to Mr. Kiddie's suggestions, another test was made by Mr. W. C. Thomas, who smelted 25 tons of material at the rate of 100 tons in 24 hours, and with a consumption of oil for smelting amounting to 11.2 gal. per ton of ore, costing 33.6 cents. The result was considered gratifying, as it confirmed the previous opinion of Mr. Kiddie.

An earlier instance of adapting oil to blast smelting is found in a furnace patented by the late J. W. Nesmith, of the Colorado Iron Works Company, Denver. This furnace was experimented with at the factory of the Colorado Iron Works Company, for several years. The only commercial plant ever turned out by the company is a 200-ton furnace owned by the Pioneer Smelting Company, near Tucson, Arizona. This furnace has been in operation for a short time, and the preliminary results lead to the belief that it will be successfully operated with crude oil as fuel.

Report of Bureau of Mines

The first annual report made by Dr. Joseph A. Holmes, director of the Bureau of Mines, has just been issued, covering the fiscal year ended June 30, 1911. The general aim and purpose of the inquiries and investigations made by the bureau under the terms of the organic act are to increase safety, health, economy and efficiency in the mining, quarrying, metallurgical and miscellaneous mineral industries of the country. The demands now being made on the bureau by both the government and the general public are such as might be expected in the case of a bureau of much longer activity and larger income. These demands are the more embarrassing because the funds at the disposal of the new bureau are less than they were for the technologic work under the Geological Survey.

The urgent needs of the bureau include new buildings, grounds and equipment; sufficient funds for the continuous operation of the mine-rescue and first-aid work; investigation of mine accidents; enlargement of fuel investigations, and new investigations looking to the prevention of mineral waste.

The first year's work of the bureau has been confined mainly to investigations into the causes of mine explosions, testing of mineral fuels, and studying mine accidents. Another of the investigations relates to smelter fumes, which in California and some other states have proved destructive to government forests. This investigation should be extended to include different types of smelters, and the behavior in these smelters of different varieties of ore, and to the various possibilities of preventing or lessening the escape of deleterious fumes in smelters.

Another minor investigation has been made in connection with furnace slags and the influence of different metals and other mineral substances on the character and value of slags; and also the influence of metals like titanium on the behavior of molten iron in the furnace. Data have been collected also on waste in metallurgical operations. Information in hand indicates a large extent of this kind of waste and the importance of further investigations to determine how it may be reduced.

The Fractional Distillation of Wood Tar by Electrical Heat

By H. K. Benson.

Inasmuch as the wood tar industry of the Pacific Northwest finds it necessary to distil wood tar in order to successfully utilize and dispose of this product, it was thought desirable to ascertain the cost of heat from an electrical source for this purpose. In these experiments the work of Richards and Matthews,[1] Morse and Frazer,[2] and of Day and Allen,[3] suggested the means and methods used. The problem as applied to wood tar consisted in ascertaining the cost viewed relatively from the improvement in the grade of products due to absolute control of heat and the utilization of all the heat.

In the distillation of wood tar in a retort heated by gas the distribution of heat is far from uniform and satisfactory control is not obtained. Excessive local heating is produced, causing the decomposition of the heavy oils, the formation of non-condensable gases, and an increased yield of coke residue. To overcome these difficulties an apparatus was designed with the following ends in view:

1. Application of heat where most needed.
2. Uniformity of heat.
3. Absolute control.
4. Elimination of "bumping."
5. Utilization of all the heat.
6. Uniform quality of fractions.

Design of Apparatus.—Several designs were attempted but only one proved satisfactory. In this the heat was applied by passing a current through nichrome wire wound outside of a distilling flask. After a series of preliminary tests, a mixture,

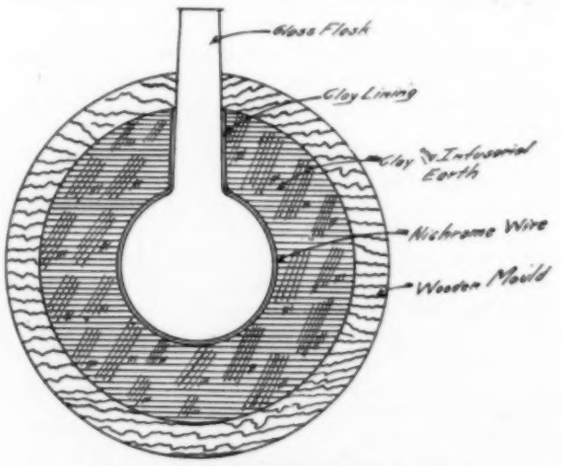


FIG. 1.—SECTION OF DISTILLING FLASK.

consisting of two parts infusorial earth and one part plastic blue clay, was selected as a desirable insulating material. Wooden moulds were made the size and shape of a distilling flask, and cut into two equal sections, lengthwise of the neck. By means of rows of pegs driven into the wood, 18 ft. of number 24 nichrome wire, having a resistance of 26½ ohms, was wound on each hemisphere. A larger hollow wooden mould (see Fig. 1) was filled with a stiff mixture of the insulating material and the hemisphere embedded. It was left to air dry over night, and put into a steam oven to bake for 24 hours. At the end of this time, a current was passed through the wire, and the wooden mould burned out, leaving the wire around the walls of the depression. After cooling, the wire was covered with a thin plastic clay, forming a smooth receptacle for the distilling flask and keeping the wire from touching the glass.

The other half was prepared in a similar manner. By placing

[1] Journal A. C. S. 30:1282 (1908).
[2] American Chemical Journal 32:93 (1904).
[3] Unpublished letters.

the two halves over the flask, it was entirely surrounded by wire and this in turn with an insulating layer 2 in. thick. The wire was wound with a view to partial concentration of the heat near the bottom of the flask, where it would be of most service.

The wires from the two sections were connected in parallel, making a combined resistance of 13 3/10 ohms at 24 deg. C. Two turns were taken about the neck of the flask to diminish the condensation in that part of the apparatus. The current used was obtained from the storage batteries in Bagley Hall, where any electromotive force from 2 to 110 volts can be obtained.

Distillation tests.—Three different tests made in the electrically heated retort show the uniformity of product obtained in this manner (see tables Test I, II, III).

TEST I.

Time	Watts	Volts	Amperes	Temp.	Weight
3:16	0.71	56	4.00	23	435.0 gms.
3:25		58	4.10	59	
3:32		56	4.05	98	
3:37		57	4.05	105	
3:42		50	3.45	106	16.2 gms. water
3:50		50	3.45	110	
3:55		43	2.90	105	
3:59		51	3.50	105	
4:04		59	4.10	110	
4:09		59	4.10	119	
4:12		67	4.50	165	
4:14		67	4.50	181	
4:19		33	2.50	188	51.7 gms. oil
4:23		45	3.00	184	
4:28		47	3.10	185	
4:35		45	2.95	190	
4:40		46	3.00	191	
4:43		45	2.95	193	31.9 gms. oil
4:51		52	3.50	213	
4:54		45	2.95	215	
5:05		47	3.05	217.5	
5:14		49	3.15	221	28.2 gms. oil
5:22		46	3.00	230	
5:35		47	3.00	236	34.2 gms. oil
5:44	1.08	48	3.10	245	

TEST II.

Time	Watts	Volts	Amperes	Temp. °C.	Weight
2:48	1.10	48	3.5	24	450.0
2:58		48	3.5	82	
3:10		49	3.5	102	
3:14		49	3.5	104	14.6 gms. water
3:24		43	3.3	109	
3:32		49	3.5	108	
3:39		52	3.7	110	
3:45		53	3.8	133	
3:50		53	3.8	165	56.4 gm. oil
3:54		54	3.8	187	
4:02		44	3.3	189	
4:08		36	2.8	193	
4:19		41	3.2	196	42.7 gms. oil
4:28		39	3.1	212	
4:42		37	2.9	213	
4:51		39	3.1	224	25.3 gms. oil
5:15		40	3.0	230	
5:23		40	3.0	250	32.1 gms. oil
5:31	1.45	40	3.0	230	

Properties of fractions.—Below 110 deg. C. water and very small quantity of light yellow oil were given off. This oil was separated and added to the next fraction. The first oil fraction distills between 110 deg. C. to 190 deg. C. and has a light amber color which becomes clear red on standing. From 190 deg. C. to 215 deg. C. a darker amber colored oil is obtained which gradually changes to a red. Between 215 deg. C. and 230 deg. C. a thicker oil is obtained which also slowly changes to a darker color. The last fraction between 230 deg. C. to 245 deg. C. produces a rich reddish oil which in a few days, becomes almost opaque. Lastly a final residue of black brittle pitch, breaking with a conchoidal fracture and of brilliant luster, is obtained.

TEST III.

Time	Watts	Volts	Amperes	Temp. °C.	Weight
2:00	1.46	57	4.15	25	430.0 gms.
2:07		50	3.4	76	
2:19		50	3.4	102	
2:27		50	2.9	101	
2:33		40	2.9	103	
2:39		41	2.9	106	
2:48		41	2.9	106	16.0 gms. water
2:54		41	2.9	109	
3:00		42	2.9	108	
3:05		40	2.85	107	
3:10		42	3.0	107	
3:16		52	3.5	107	
3:22		55	3.75	120	
3:27		54	3.70	168	50.5 gms.
3:34		41	2.85	190	
3:34		41	2.85	189	
4:17		41	2.85	213	44.3 gms.
4:30		42	2.9	216	
4:40		42	2.9	228	23.2 gms.
4:48		44	3.0	230	
5:00		43	2.9	244	27.0 gms.

The nature of these fractions is further indicated by the following results:

Test	110°C. Sp. Gr. 20°C.	190°C. Viscosity 20°C.	190°C. Sp. Gr. 20°C.	215°C. Viscosity 20°C.	215°C. Sp. Gr. 20°C.	230°C. Viscosity 20°C.	230°C. Sp. Gr. 20°C.	245°C. Viscosity 20°C.
I.	1.026	1.44	1.031	1.25	1.030	1.23	1.023	1.57
II.	1.027	1.46	1.032	1.16	1.032	1.31	1.025	1.54
III.	1.025	1.42	1.032	1.23	1.031	1.23	1.024	1.85
IV.*	1.020	1.19	1.027	1.16	1.026	1.23	1.029	1.16

*Fractions obtained by distillation with gas flame.

Test with gas-heated retort.—For comparison purposes the usual gas-heated retort was used and the distillation conducted under ordinary laboratory conditions. The oils obtained in the various fractions were of a cloudy appearance, and a considerable quantity of white fume was formed. This test is designated as IV in the following tabulated summary of results:

Test	Tar Gms.	Water %	110°C. 190°C. %	190°C. 215°C. %	215°C. 230°C. %	230°C. 245°C. %	Pitch %	Time H. M.	Watts
I.	435	3.72	12.00	7.33	6.48	8.00	62.70	2:28	370
II.	450	3.25	12.53	9.50	5.62	7.13	62.00	2:43	350
III.	430	3.72	11.74	10.30	5.39	6.30	62.55	3	370
IV.	429.5	3.33	13.00	7.07	5.14	7.70	63.60	2:15	15 cu.ft.

Cost of electricity.—The comparison of cost of electricity with gas must, of course, be considered from the standpoint of market price. The cost of gas for domestic use ranges from 80 cents to $1 per 1000 cubic feet. Using 70 cents as the cost of gas delivered would make the cost of 15 cubic feet to be 1.12 cents. To distill a like quantity of tar by electricity requires 370 watt-hours. The cost of electricity for power purposes ranges from 3 cents to as low as 6/10 of a cent per kw-hour. In view of the fact that this would be a desirable load to carry, since it could be run off peak or as a 24-hour load, a price of 1 cent per kw-hour could be realized. On this basis the use of 370 watt-hours would cost less than 4/10 of a cent.

The general conclucion reached is that distillation of wood tar by heat from electricity will yield a larger quantity and a higher grade of oils than by heat from flames. Compared with gas as a fuel, electricity is much cheaper and probably compares favorably with the cheaper fuels in economy. The ease with which distillation can be controlled, and the decrease of danger from fire are among the advantages of this method.

The experimental work, described in this article was done under the author's direction by C. E. Brown and G. B. Shadinger, forming a portion of a thesis submitted for the degree of B.L. in electrical engineering at the University of Washington.

The Relation Between Temperature and Viscosity of Lubricants.

The Ellis-Elebash Temperature—Viscosity Law.

By R. L. Ellis.

The purpose of a lubricant is to reduce, or, as nearly as possible prevent, friction. In a lubricated bearing the friction is of two kinds, viz.: that due to the attrition of the rubbing surfaces and that due to the internal friction between the molecules of the lubricant itself. The lubricant reduces the friction of attrition by interposing a film of the lubricant between the rubbing surfaces and thereby keeping them more or less perfectly separated. The relative motion of the rubbing surfaces with the film of lubricant interposed sets up internal friction in the lubricant itself.

From this it will be evident that the lubricant with the least internal friction, which will keep the rubbing surfaces separated, will reduce the total friction to a minimum. This internal friction of a lubricant is usually termed viscosity or body, so

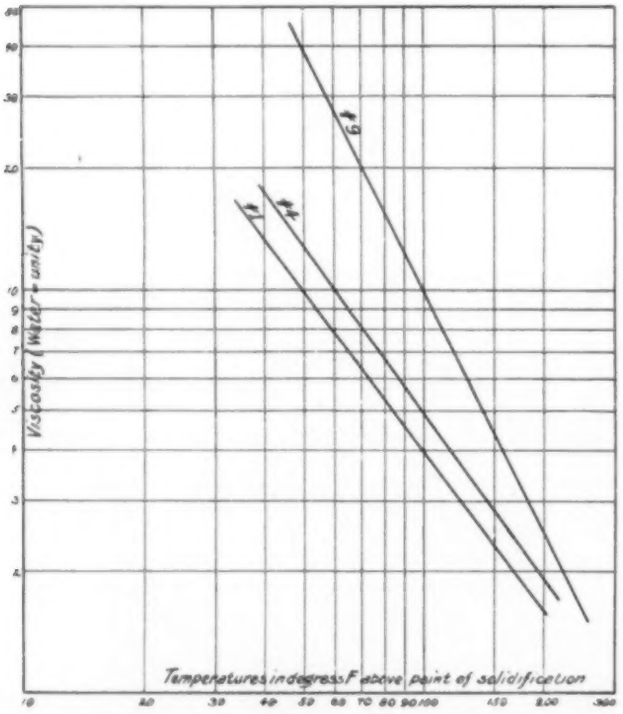


FIG. 1.—TEMPERATURE—VISCOSITY DIAGRAM.

that the above statement might be paraphrased by saying that the best lubricant for a given service is the one with the least viscosity which will produce the necessary film between the rubbing surfaces, or it is the thinnest lubricant which will stay in place and do the work.

It, therefore, follows that, broadly speaking, and within certain limits, viscosity may be taken as the measure of value of an oil for lubricating purposes. And granting this, the determination of viscosity, and the extent of its variation, is a matter of considerable importance in the proper selection of oils for lubrication. In general, viscosity is independent of specific gravity, cold test, flash point or fire test, but is a function of the kind of oil and the temperature at which determination is made. It should be stated, however, that while the viscosity is independent of the specific gravity of the oil, nevertheless, its determination by means of the pipette type of instrument is more or less affected by the specific gravity.

It is possible, moreover, to add certain ingredients to an oil which will materially affect the determination of the viscosity as made by means of the pipette type of instrument, but which do not add to its value as a lubricant. And, again, some of these artificial loadings add largely to the viscosity at low temperatures but do not sensibly affect it at the higher temperatures. From this it is apparent that it is not altogether safe to place too great confidence in the viscosity of an oil as determining its fitness for a given use without a knowledge of some of its other properties or characteristics. Nor can we confidently predict the probable lubricating value of an oil at one temperature from a knowledge of its viscosity and known lubricating value at some other temperature. For while the viscosity of an oil, in general, varies inversely with the temperature, the rate of change is not uniform as between different oils, nor is the rate of change uniform over any wide range of temperature changes in the same oil.

Although the viscosity of an oil, by and of itself, is not conclusive as affording a measure of its lubricating value, it is nevertheless probably the most important single characteristic as affecting this value. And while this fact has been generally conceded by the best informed, the application of the knowledge in determining the suitability of an oil for a specific service is a problem not unattended with considerable difficulty. The great majority of the users of lubricants have not recognized the importance of this problem, and its complexity has deterred many who have recognized its importance from seeking a solution. It is no small undertaking to determine the viscosity of any considerable number of oils over the wide range of temperatures and at the close intervals necessary to predict with any degree of certainty what the viscosity will be at any prede-

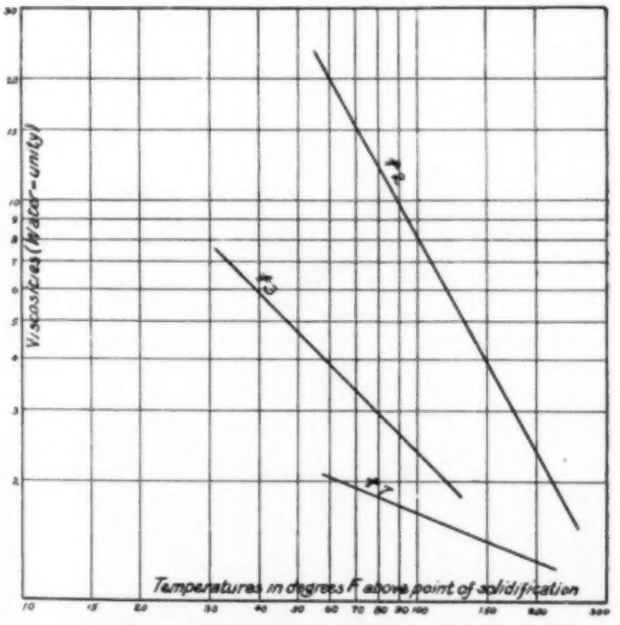


FIG. 2.—TEMPERATURE—VISCOSITY DIAGRAM.

termined temperature. And without this very intimate knowledge of the exact relationship existing between temperature change and the corresponding viscosity change for each oil proposed, the consideration of viscosity in its relation to lubricating value is of small utility.

Being confronted with the desirability of knowing the viscosity of an oil at widely differing temperatures and at frequent intervals it becomes evident that it is a matter of considerable interest and importance to ascertain if there be not some general law connecting temperature change with the corresponding viscosity change, since it is reasonably to be expected that such a law would greatly simplify the process of such viscosity determinations for a large number of temperatures. Recognizing the desirability of some simple method of predicting with reasonable certainty the viscosity of a given oil for different temperatures without the necessity for a separate determination for each, an attempt was made to ascertain

if there be not some law applying to at least some considerable number of lubricating oils likely to be met with in practice.

In making the attempt to find such a law, a large number of separate determinations were made covering oils of widely different characteristics and over a large number of temperature changes. These determinations were supplemented by data obtained from different sources covering substantially the same information. After this information was tabulated and classified curves were drawn on rectangular cross-section paper an attempt was made to recognize the shape of the curves and if possible determine the equations representing them. Or failing this, to ascertain if it were possible to approximate the curves by determining a relatively small number of points in each case.

The resulting curves appeared to be all of the same general shape and to the eye closely resembled the polytropic curve of expansion of elastic media corresponding to the general equation $PV^n = C$. The natural limitations of the human mind

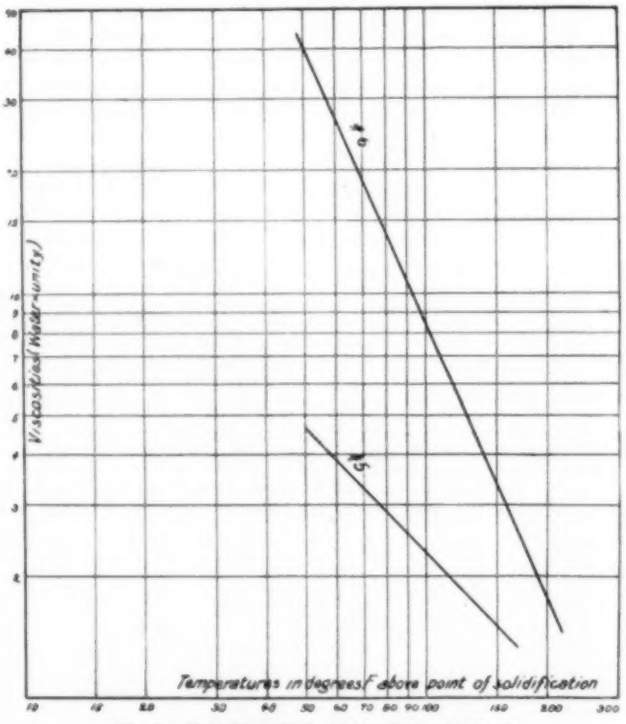


FIG. 3.—TEMPERATURE—VISCOSITY DIAGRAM.

are such, however, that we are not able in general to distinguish between curves, especially when they approximate the same general form. It is doubtful if the investigation would have gotten past this stage had it not occurred that one of the curves corresponding to the special case of the curve wherein the value of n is unity. In this case the temperatures were plotted from 0 deg. Fahr. and represented the base. The viscosities were taken with reference to water (and are therefore specific viscosities rather than absolute) and used for ordinates, being plotted from zero also. With these conditions, this curve corresponded at almost every point to the equation

$$TV = C,$$

and was consequently rather easily recognized.

This close correspondence of the curve with this equation throughout the whole part plotted, and the similar shape of the other curves led to the belief that possibly the other curves corresponded to the general equation if proper values could be found for n and C and provided the proper origin be selected for T and V. The plotting of this polytropic curve on rectangular cross-section paper gives a curve depending for its form and position on the values of T, V, n and C. When, however, this curve is plotted on logarithmic paper it becomes a straight line which depends for its position on C and for its slope on the value of n.

The relationship of the curves is as follows:

Being given

$$TV^n = C.$$

Then,

$$\log T = -n \log V + \log C.$$

This assumes the same form as the equation for a straight line,

$$Y = aX + B$$

Where $Y = \log T$, $s = -n$, $X = \log V$, $B = \log C$.

And thus $s = -n$ represents the slope of the line to the axis $\log T$ and is numerically determined by taking two points on the curve and determining the value of the ratio,

$$\frac{OY}{-OX} = -n,$$

the value of the ratio being negative on account of the measurement being toward the left on OX and hence negative.

For a time we were at a loss to understand why the temperatures taken as above 0 deg. Fahr. scale should give a straight line characteristic since this point represents no very definite point as does the zero on the Centigrade scale. This

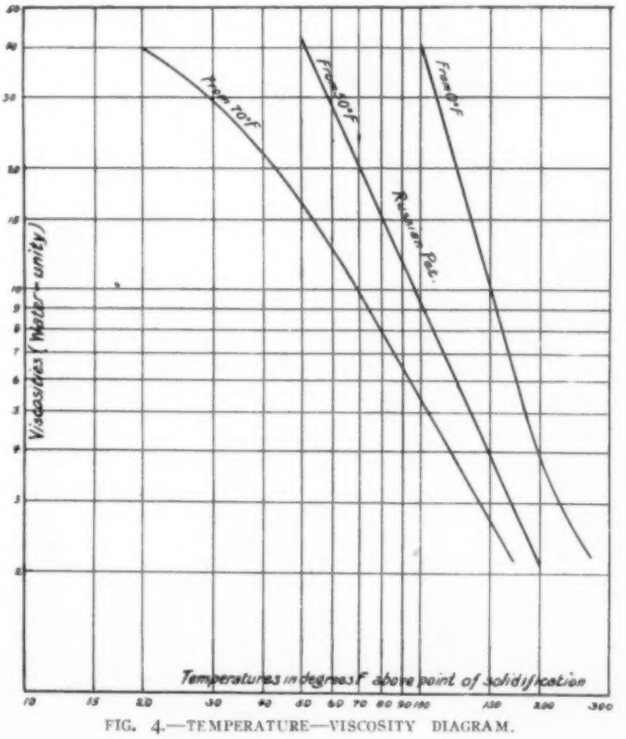


FIG. 4.—TEMPERATURE—VISCOSITY DIAGRAM.

was made clear when we discovered that some of the oils, especially the more viscous petroleum products, when plotted in temperatures above zero Fahr. did not give a straight line, and it became necessary to alter the point of origin. It was then discovered that the oils giving a straight line for which the origin was taken from zero Fahr. completely solidified at or about this point, and that the other oils if plotted with their temperatures of complete solidification as the origin gave substantially straight-line characteristics.

In few cases, if any, were we able to get all of the points exactly on a straight line, nor were we able to get two successive determinations of viscosity to agree exactly in value except in rare cases. This was especially noticeable at temperatures much above or below room temperature.

The tendency of all of the viscosities, for the different oils for which determinations were made by those conducting the investigation, was to deviate from the straight-line characteristic both at high and at low temperatures. At temperatures

Temperatures and Corresponding Viscosities of Various Oils.

1. OLIVE.		2. RAPE.		3. SPERM.		4. NEATSPOOT.		5. AM.PET. 885 S.G.		6. AM.PET. 923 S.G.		7. AM.PET. "B"		9. RUS.PET.884 S.G.	
Deg. F.	Visc.	Deg. F.	Visc.	Deg. F.	Visc.	Deg. F.	Visc.	Deg. F.	Visc.	Deg. F.	Visc.	Deg. F.	Visc.	Deg. F.	Visc.
23	Solid	0	Solid	25	Solid	0	Solid	0	Solid	0	Solid	0	Solid	50	Solid
70	10.90	....	....	....	..	40	15.69	50	4.51	50	44.44	60	1.95	100	39.80
100	5.45	60	21.20	60	6.95	55	11.11	60	4.12	60	26.60	80	1.86	110	29.00
120	4.09	70	15.09	70	5.37	71.5	8.36	70	3.53	70	19.00	95	1.77	120	20.80
160	2.72	80	12.80	80	4.43	85	6.22	80	2.86	80	14.70	110	1.61	130	15.60
		90	10.20	90	3.76	100	5.11	90	2.47	90	10.30	125	1.56	140	12.40
		100	8.36	100	3.15	110	4.53	100	2.12	100	7.85	140	1.47	150	9.80
		110	6.63	110	2.76	122	3.97	110	1.96	110	6.00	150	1.44	160	7.85
		120	5.77	120	2.37	140	3.20	120	1.84	120	4.95	175	1.36	170	6.31
		130	4.83	130	2.23	158	2.69	130	1.76	150	2.77	200	1.27	180	5.25
		140	4.12	140	2.00	176	2.23	140	1.61	180	2.06			200	3.88
		150	3.72	150	1.92	203	1.86	150	1.51	210	1.57			220	3.02
		160	3.33											250	2.31
		170	2.98												
		180	2.70												
		190	2.51												
		200	2.28												
		210	2.12												
		230	1.86												
		250	1.70												

greatly below that of the surrounding atmosphere the viscosities tended to run low and at high temperatures to run high. The more the oil temperatures deviated from room temperatures the more marked this tendency became. After discovering the apparent applicability of the curve $TV^n = C$ to temperature-viscosity variations a considerable number of the determinations were remade in order to determine, if possible, the reason for this discrepancy.

In remaking these determinations great care was exercised to insure uniform temperature throughout the whole mass of oil, to detect if there were any change in the temperature during the test period, and to determine if the temperature of the oil at the nozzle were the same as in the oil mass. When we were able to maintain practically uniform test conditions as above we found in each case the points fell much nearer the straight line, but in general the points at the extremes of temperatures did not fall exactly on the line. The more accurately the tests were made the more nearly the points conformed to the general law.

Plotted curves from data, obtained from our own determinations and from other sources, we would occasionally find a single point which fell entirely away from the line. In making a redetermination of our own data for the particular point, we invariably found that an accurate determination brought the point practically on the line and it is assumed that the same would be true of the data from other sources, though there was no means of checking this.

The commercial form of viscosimeter is hardly to be considered an instrument of precision, and unless all of the conditions of its use are rigidly maintained constant during a determination the aggregate of the errors are likely to be rather large. The sources of error encountered seem to have been due to the temperature not being uniform throughout the oil mass and the rapid change of temperature at the efflux nozzle, these being more noticeable where the temperatures differed greatly from that of the surrounding air. The change of specific gravity in the oil with the change in temperature, of course, has more or less influence on the determinations made on this type of instrument, but the errors due to this change are necessarily rather small.

Several curves are submitted herewith showing the characteristics of several varieties of lubricating oils. These are grouped for non-interference on the sheets rather than for any reasons of similarity of the oils, although some of the oils on the same sheet show very similar curves. On sheet 4 are shown several curves to illustrate the departure of the curve from a straight line due to taking the temperatures from different temperatures; one from the point of solidification, and one each from temperatures above and below this point.

The number of separate determinations of viscosity tabulated and studied do not cover a wide enough range either in temperatures nor in kinds of oils, nor is the accuracy of these determinations believed to be of sufficient accuracy to enable it to be said that the law holds universally. However, it is believed that the very close correspondence to the law of data obtained from widely different sources makes it more than probable that the law holds throughout the ordinary range in temperatures and for the oils likely to be met with in ordinary use, and more than possible that it holds universally.

The Ellis-Elebash law may be stated as follows: In any lubricating oil a change in its temperature is accompanied by a corresponding change in viscosity, and if T represents the temperature in degrees above its point of complete solidification, and V represents the corresponding viscosity relative to water (water being considered as unity), then the rate of change in viscosity corresponding to a change in temperature is such that it is represented by the polytropic curve corresponding to the equation

$$TV^n = C,$$

in which n is a coefficient depending upon the particular oil under test and C a constant which also depends upon the particular oil. n might be termed the modulus of viscosity.

The practical application of the law is that: Given the point of complete solidification of the oil and two determinations of viscosity (preferably at rather wide variation of temperature) it is possible by plotting the curve on logarithmic paper to determine with substantial accuracy the viscosity at any other temperature within the range over which oils are likely to be needed for lubrication. Or failing the point of solidification and given three viscosity determinations (as above) it is possible to determine the point of solidification by method of trial and error, and to determine the viscosity at other temperatures as first stated.

Consequently, since in practice an oil which has a reasonably small viscosity change with a given temperature change (above and below the working temperature) is most desirable, the law forms a simple and effective means of determining the extent of this variation by means of the inclination of the line to the axis log T.

Selma Lighting Co.,
Selma, Ala.

If working cyanide solution contains lime, or lime salts, and it is necessary to drip strong cyanide solution into the working solution just before it comes in contact with the zinc, it is inadvisable to make this strong solution from solid cyanide containing alkaline carbonates in any appreciable quantity, otherwise the resulting precipitate of calcium carbonate will be a source of loss and expense in the subsequent smelting.

Plug cocks cause trouble on high-pressure water-service pipes, especially when they are at, or near, the end of a long line. The rapidity with which such cocks can be closed causes shocks, if not bursts, on the pipe line.

Notes on Chemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

Ancient Indian Iron.

Sir ROBERT HADFIELD recently secured specimens from the noted iron pillar of Delhi which have given the following results on analysis—the iron having been actually determined: Carbon, 0.08 per cent; silicon, 0.046; sulphur, 0.006; phosphorus, 0.114; iron, 99.72; total, 99.966. Specific gravity, 7.81, It is noteworthy that manganese is absent. Sir Robert is of opinion that this is the first complete analysis of this iron which has been published. It shows that Indian metallurgists more than a thousand years ago could produce wrought iron of excellent quality; and the very low sulphur content points to their care in selecting pure fuel. In his paper on "Ancient Sinhalese Iron and Steel," read at the May meeting of the Iron and Steel Institute, Sir Robert gave interesting particulars of this remarkable pillar. It is a solid shaft of wrought iron, upwards of 16 in. in diameter and 22 ft. high, consisting of blooms of about 80 lb. weight each welded together; but the welding is not uniformly good. It probably dates from about 300 A. D. Some three years after the Iron and Steel Institute was formed, special inquiries were made by the committee concerning this pillar (1872, Vol. II, page 156); and Lieutenant Spratt, R. E., then stationed at Delhi, gave the height of the column above the ground as 24 ft., the depth underground as 3 ft., and reported that the lower end is a bulb like an onion and rests on eight short thick iron rods, the inferior extremities of which are leaded into blocks of stone.

Coal Dust Explosions.

The construction of the experimental station at Eskmeals, Cumberland, which was begun in September last, has been delayed by the coal strike and other causes, but is now approaching completion, and it is expected that in about a month experiments on a large scale will be begun under the direction of the consultative committee consisting of the members of the Royal Commission on Mines and the Coal Dust Committee of the Mining Association.

The main equipment consists of three steel galleries, the largest of which has been transferred from the old station at Altoft's colliery. It consists of old boilers, and has a length of about 800 ft. with a diameter of 7 ft. 6 in. It runs east and west, resting on sleepers laid on the shingle; and at the eastern end two turns at right angles bring a return arm, parallel with the main tube, to the fan house. By the side of the main gallery there is a smaller tube 400 ft. long constructed of flue pipes, 3 ft. in diameter, carried on concrete pillars; and by means of curved tubes at both ends this tube can be joined up to the main gallery. Provision of compartments for containing gaseous explosive mixtures will allow a gas explosion in the small tube to start a dust explosion in the main tube. Instruments for recording pressure and velocity are stationed between the two tubes in a series of huts, each of which is provided with apparatus for taking photographs of the explosions through glass-covered slits on a disk rotated at a speed greater than that of the propagation of the explosions. For preliminary experiments there is a third tube, further to the north, 150 ft. long and 1 ft. in diameter, connected with a gasometer holding 1500 cu. ft. and with a fan. The adjustment and reading of the recording instruments will be effected at the chronograph house, which will be provided with a large photographic darkroom. To the south of the main gallery there are various buildings accommodating accessory plants. Power is derived from two 25-hp Robey engines driving two dynamos, one of which generates current at 200 volts and the other at 100 volts; and the battery room contains 60 chloride cells. Gas-making and coal-crushing plant, a lamp-testing station, together with physical and chemical laboratories complete the equipment of the station. The whole of the arrangement appears to have been carried out with great care and foresight, and there is every reason to anticipate the attainment of conclusive results in the near future.

The Institute of Metals.

For the first time since the formation of the Institute the annual autumn meeting will be held in London on Sept. 25 and 26 at the Institution of Electrical Engineers. The mornings will be devoted to the reading and discussion of ten papers, and the afternoons to inspections of Messrs. Fraser & Chalmers' works at Erith, the National Physical Laboratory and Woolwich Arsenal. A visit to the Brooklands motor race course and aviation ground has also been arranged with the view of witnessing the competition for the aviation prize offered by the Institute.

Quick Combination Methods in Smelter Assays.

A paper bearing this title, recently read before the Institute of Mining and Metallurgy, has elicited the subjoined communicated remarks from Mr. J. H. LEVINGS. As chief assayer of a large customs smelter he made thousands of lead determinations by various methods, and finally exclusively adopted Alexander's method, which, after severe testing against English and German assayers, was found very accurate. The solutions were filtered hot, after the lead sulphide had subsided, and with good filter paper and re-filtration of the first portions the loss was negligible. Lime does not ordinarily interfere, but it is as well to remove the beaker from the hot plate as soon as the first fumes of sulphuric anhydride appear; and the drop of nitric acid adhering to the cover-glass will do no harm. But in the assay of flue dust containing 30 per cent lead and 10 per cent lime Alexander's method gave results about 2 per cent too high, and for such flue dust another method was adopted. The applicability of the method to ores containing over 5 per cent antimony depends upon the method of breaking up the ore. For ores containing 10 to 30 per cent antimony the author uses the same mixture as for attacking base bullion, viz., 3 parts nitric acid, 2 parts water, and 1 part tartaric acid, by weight. About 20 cc. of this mixture are used for attacking, and when the ore is broken up 7 cc. of sulphuric acid are added; the vessel is then placed on the hot plate, and when the color of the gas bubbles—which is at first brown—becomes pale it is removed from the hot plate and the action will generally go on by itself until the evolution of colorless gas shows that nitric acid has been driven off. Too prolonged heating decomposes the tartaric acid. After dilution the whole is boiled and the remaining operations are conducted in the usual way.

Another way of attacking antimonial lead ores is to first warm with hydrochloric acid for ten or fifteen minutes and then add enough nitric acid to decompose all sulphides on heating. The sulphuric acid is then added, and the whole is evaporated until sulphuric anhydride is given off, and the usual procedure is followed.

Engineering Imports and Exports.

The returns by the Board of Trade for the half year ended on June 30 are not completely satisfactory on account of decreases in exports. The imports of iron and steel, including manufactures, totalled £5,713,864, an increase of £28,298 as compared with the corresponding period of 1911, and exports were £21,550,651, a decrease of £609,990.

Imports of other metals, including manufactures, amounted to £14,516,123, an increase of £1,069,185, and exports were valued at £5,543,038, an increase of £57,275. In electrical goods the imports touched £721,821, and increased £33,301, while exports, put at £2,066,333, showed an increase of £711,900. Imports of machinery were £3,427,375, a rise of £278,727, and exports figured at £15,689,186, and showed a decrease of £40,222. Imports of new ships reached only £14,302, a decrease of £33,638, but exports went up to £2,696,590, an increase of £164,344.

Taking the month of June only the imports showed an increase of £89,260 for iron and steel; an increase of £136,314

in other metals; a decrease of £8,128 in electrical goods; an increase of £39,238 in machinery, and an increase of £612 in ships. Exports exhibited a decrease of £167,445 in iron and steel; a decrease of £75,650 in other metals; an increase of £85,292 in electrical goods; a decrease of £210,630 in machinery, and a decrease of £129,060 in ships.

Market Prices.

July.

Tin has kept within closer limits than usual, but has been down to £196 (18th) and, generally speaking, under the £200. Bettering at the close of the month it closes at £203.

Copper exhibits an upward tendency, £75.7.6 on the 17th, £76.10.0 on the 19th, and £78.15.0 by the 23rd. It closes at £78.0.0.

Iron, Hematite opened at 73/6 and has kept fairly strong. closes at 74/7½.

Iron, Cleveland has improved considerably, and even touched 58/9 during the week preceding July 28. It closes at 58/3.

Alum lump, per ton	£5.15. 0
Antimony, black sulphide powder, per ton	20. 0. 0
Borax, British refined crystal, per ton	17. 0. 0
Copper ore, 10 to 25 per cent, per unit	13/6 to 14. 6
Copper sulphate, per ton	24. 5. 0
Carbolic acid, liquid 97/99 per cent, per gal.	1. 6½
Creosote, ordinary good liquid, per gal.	3¼
Caustic soda, Ash 48 per cent ordinary, per ton	5.10. 0
Hydrochloric acid, per cwt.	5. 0
India rubber, Para fine, per lb.	4.11½
Naphtha, solvent, 90 per cent, 160 deg. C., per gal.	2. 9
Petroleum, Russian spot	8
Quicksilver, per bottle	8.10. 0
Sal ammoniac lump, firsts, delivered U. K., per ton.	44. 0. 0
Sulphate of ammonia, f.o.b. Liverpool, per ton	14.12. 6
Sulphur, recovered, per ton	5. 0. 0
Shellac, Standard T. N. Orange Spots, per cwt.	4. 4. 0
Tin ore, 70 per cent, per ton	£133 to 135. 0. 0
Zinc, Vielle Montagne, per ton, f.o.b. Antwerp	29. 7. 0
Platinum, nominal	9. 5. 0.

The differences on the month are thus:

Higher.

Borax, ton	£0.10. 0
Tin ore	1. 0. 0
Tin	5. 0. 0
Copper	1. 0. 0
Hematite	1. 0
Cleveland	9

Lower.

Copper sulphate	£0.10. 0

The Testing Laboratory of the Conservatoire National des Arts et Mètiers in Paris.

The yearly report for 1911 of the Laboratoire d'Essais du Conservatoire National des Arts et Métiers has appeared.

This Testing Laboratory, founded in 1900, was organized in 1901 with the financial aid of the Paris Chamber of Commerce, for the purpose of permitting manufacturers, engineers and others to submit their products, of any kind, machines and apparatus, so as to have official tests made.

The domain of the Laboratory comprises the whole field of physics (except electricity), the metals, materials of construction, all machines, except electrical machines, and their accessories, fuels, etc. The Laboratory also carries out the official legal verification of alcoometers, densimeters, and thermometers. The work is distributed among five sections.

Not only the number of test orders, but the receipts of the Laboratory have increased during the past. The receipts have increased from $18,000 in 1910 to over $21,000 in 1911, not including the receipts for the verification of alcoholometers and thermometers which amounted to $5,400.

Recent Metallurgical and Chemical Patents.

Electric Furnaces.

New Refractory Compound of Silicon and Carbon.—Dr. Edward G. Acheson, of Niagara Falls, N. Y., describes a method of making a new compound which may be chemically identical, at least very nearly, with SiC, but is distinguished by greater toughness and smaller brittleness. Its toughness in conjunction with extreme hotness indicates abrasive qualities of exceptional value. It was obtained as follows: A mixture was prepared consisting essentially of pure silica sand and carbon commingled in the proportions theoretically required for the production of silicide of carbon, that is to say in the proportion of 62.7 parts of sand to 37.3 parts of carbon. To this mixture was added a second mixture consisting essentially of boric acid from which most of the water of crystallization had been expelled, and carbon, the boric acid and carbon being in the approximate proportions of 210 parts of B_2O_3 to 120 parts of carbon. These two mixtures were thoroughly commingled in various proportions, the proportions in one specific instance being 92 parts of the silica mixture to 8 parts of the boric acid mixture. The resulting mass was heated in an electric furnace of the resistance type, being disposed in proximity to the resistor and carefully shielded from the action of the air. The temperature was approximately that required for the production of carborundum and was maintained for several hours. Boron may be or may not be in the final product. In the latter case characteristic properties of the product are probably "due to the modifying influence, during the reaction, either of the boric anhydride or of the products of reduction thereof. In such case it is reasonable to suppose that other bodies may prove capable of exerting a like favorable effect upon the toughness of the product." (1,014,199, Jan. 9, 1912.)

Dense Silicon Carbide.—Mr. Frank J. Tone, the works manager of the Carborundum Company, of Niagara Falls, patents a kind of silicon carbide which is evidently identical with what is known abroad as silundum. If carbon, either in its amorphous form or in the form of graphite, in segregated or solid masses, rather than mixed with silica, in pulverized form, is heated in proximity to silicon or silicon compounds, the fused or volatilized silicon penetrates the pores of the carbon and forms silicon carbide in situ, and this product possesses new, peculiar and useful properties. For example, if a carbon rod or other carbon article be embedded in a mass of silica and carbon, or carborundum, or silica, or other silicious compound, and subjected to the temperature of formation of silicon carbide, there is produced to a greater or less depth on the surface of the rod a dense form of silicon carbide, which is non-porous and very solid. Chemical analysis shows that this product often contains free silicon in quantities up to four per cent, and Mr. Tone believes that this silicon when present may assist in cementing the silicon carbide crystals together. The product has a hardness about equivalent to that of silicon carbide produced in the ordinary manner, but has much greater toughness. If the carbon article is thin, it is possible to convert it entirely into dense silicon carbide. If the carbon piece is of some special form—as, for instance, in the form of a crucible or plate, it is possible to convert this, without changing its form, into dense silicon carbide. It is also possible to convert only the surface of the carbon article into dense silicon carbide, thus forming a silicon carbide lining or film on a carbon article. (1,013,700 and 1,013,701, Jan. 2, 1912.)

Cyanamide.—Dr. Albert R. Frank, of Spandau, Germany, points out that in the reaction between calcium carbide and nitrogen resulting in the formation of calcium cyanamide and carbon it is not necessary to heat the whole mass to the reaction temperature. It is only necessary to start the reaction at one single point by heating the mass at that point to the correct temperature. Then the reaction will proceed from there throughout the whole mass. (The reason for this is, of course.

that the reaction evolves enough heat to heat the surrounding parts to the temperature required to start the reaction and so on.) The reaction temperature is between 800 and 1100 deg. C. A method of electric heating is described in which the carbide is packed in a cylinder with a resistor rod in the center, the carbide surrounding the resistor. Nitrogen gas is introduced into the cylinder and when the resistor heats the particles next to it to the proper temperature the reaction starts and proceeds to the outside. (1,010,404, Nov. 28, 1911.)

Aluminum, Magnesium, Nickel.

Electric Melting in a Vacuum.—The use of electric heat applied in a vacuum for melting such metals ase are subject to oxidation when melted in air, is the basis of a patent granted to WILLIAM S. SIMPSON, of London, England. As shown in Fig. 1. the apparatus consists of a metal container *A* adapted

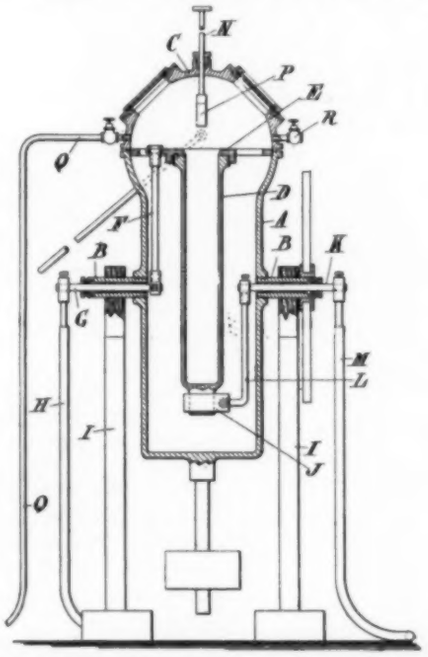


FIG. 1.—APPARATUS FOR ELECTRIC MELTING OF METAL IN A VACUUM.

to be swung on trunnions *B*. This container is covered by a cap *C* having observation ports. A crucible of carbonaceous material is shown at *D*, and the space between the crucible and container is packed with non-conducting, heat-insulating material. Electric current is applied to the top and bottom of the crucible at the ring *E* and clamp *J*, as shown, being conducted through the wires *H* and *M*, and passing through the trunnions. A stirrer is provided at *NP*. By use of this apparatus, metals such as magnesium, aluminum and calcium, which readily oxidize when melted in air, may be melted and alloyed in a vacuum. The generation of electric heat is effected with great economy, and there is little damage to the apparatus as a result of the heat. (1,015,091, Jan. 16, 1912.)

Electrolytic Furnaces.

Electrolytic Furnace Process for the Production of Cyanides and Cyanamides.—Mr. CHARLES E. ACKER, of Ossining, N. Y., to whom was due the only fused electrolytic cell for production of caustic soda and chlorine (which was in commercial use for several years in Niagara Falls until the plant burned down) describes a modification of the cell for the production of the cyanides and cyanamides of alkalies and alkali earth metals. One of the constructions is shown in Fig. 2. Fused sodium chloride or sodium hydroxide 7 is electrolyzed in a cell with anodes 5 and a layer 6 of fused lead in the bottom of the cell as cathode. The sodium set free at the cathode alloys with the lead and the sodium-lead alloy is carried off into a reaction chamber 10^3 where a reaction is brought about with nitrogen or ammonia and with carbon. The sodium is then returned to the cathode.

"Specific processes which may be carried out are the production of sodium cyanamide or cyanide by the injection of ammonia or nitrogen into the molten sodium-lead alloy resulting from the electrolysis of sodium hydroxide, or chloride upon a lead cathode, in the presence of charcoal or other carbonaceous reagent. When the electrolyte is molten sodium chloride and ammonia is used as a source of nitrogen, it is important to cool the alloy in transit from the electrolytic cell to the reac-

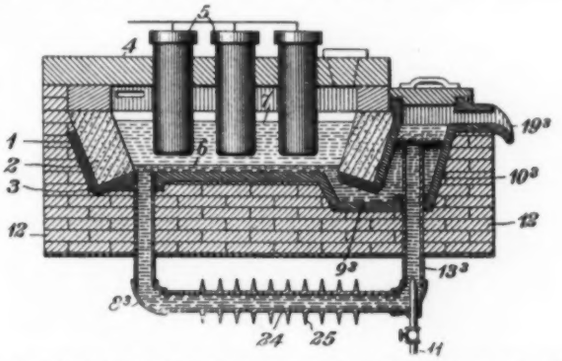


FIG. 2.—ELECTROLYTIC FURNACE FOR THE PRODUCTION OF CYANIDE.

tion chamber, and this cooling may be effected either by the transfer of heat to a returning stream of cooler residual metal, or otherwise, as by the heat radiating devices shown in the illustration.

"When the electrolyte is molten sodium hydroxide, it is unnecessary to cool the alloy, and its temperature is not sufficiently high to decompose the injected ammonia. Furthermore, instead of employing a simple electrolyte of molten common salt, other salts or compounds may be mixed therewith for the purpose of lowering the melting point or increasing the fluidity. The fluorides and chlorides of the alkali and alkaline-earth metals may be employed for this purpose, and the temperature of the alloys may thus be made so low that it will be practically unnecessary to cool the alloy before injecting the ammonia. The particular reaction which takes place in the chamber 10, due to the simultaneous or successive action of nitrogen or ammonia and carbon depends on the temperature in this chamber. If the temperature be low, say about 500 deg. C., the sodium in the alloy is initially converted by ammonia into sodium amide and this amide, in contact with the carbon, is then converted into disodium cyanamide, which is stable and will be discharged as its level rises above the outlet of the chamber. For the continuous production of cyanamides, sodium hydroxide may be employed as an electrolyte, and the alloy, at a lower temperature, passing to the reaction chamber may then be heated by hot residual metal returning from this chamber to the cell. The anodes in this case are preferably of iron, nickel or ferro-nickel, and a lining of solidified sodium hydroxide may be maintained on the side walls of the electrolytic cell, cooled by water circulated through them. For the continuous production of sodium cyanide, molten sodium chloride may be electrolyzed and the resulting alloy delivered, without cooling, into the reaction chamber, and there treated with nitrogen and carbon, the temperature in this chamber being sufficiently high to maintain the cyanide in the molten condition. The chamber may be heated by an alternating current passed through the supernatant molten cyanide, or sodium amide or disodium cyanamide may be produced, as an intermediate product, and then converted into cyanide, in the presence of carbon, by raising the temperature in the reaction chamber." (13,316, Nov. 21, 1911.)

Gas Reactions.

Ozonizer.—Mr. ROSS MORTIMER LEGGETT, of Ann Arbor, Mich., uses in his ozonizer a glass tube as dielectric with an

inside electrode consisting of a piece of sheet metal wrapped in tube form, with projections extending outward toward the glass tube. Around the outside of the glass tube a second electrode of woven wire is wound. The two electrodes are, of course, connected to the terminals of a high-tension circuit. The air to be ozonized is passed through the apparatus by means of a fan. (1,010,777, Dec. 5, 1911.)

Electrolytic Processes.

Electrolytic Amalgamator for the Precipitation of Gold.—An electrolytic amalgamator by Mr. John Frey, of San Francisco, Cal., is shown in Fig. 3. A cylindrical cage 2, which revolves about the axle 5, acts as anode. The trough

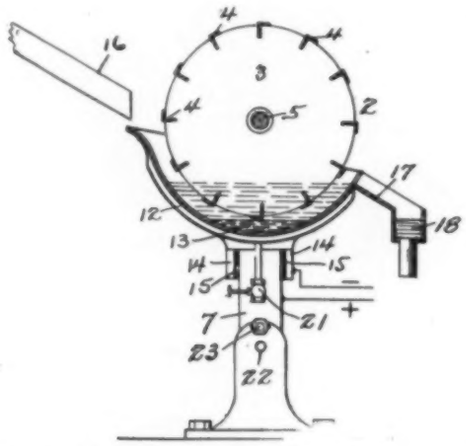


FIG. 3.—ELECTROLYTIC AMALGAMATION APPARATUS.

12, containing mercury, acts as cathode. The cylindrical cage 2 is formed of two end discs and parallel and longitudinal strips 4, all made of metal, so as to form a rigid structure, and act as conductors of the current. The drough 12 contains a quantity of mercury 13, but not so much as to cause a short circuit with the cage 2. The liquid mass to be treated as it comes from the stamp mill is fed by the spout 16 into the drough, and the residue is discharged over the apron 17. The apparatus is said to be particularly efficient when the gold occurs as free gold or fine float gold, and when a large percentage of slime occurs in the material coming from the stamp mill. With certain kinds of ores it is desirable to mix cyanide solution with the ore. (1,009,143, Nov. 21, 1911.)

Mercury Cathode Cell.—A patent by Dr. R. Frank, of Grunewald, Berlin, Germany, describes a mercury cathode cell the principal feature of which is the continuous movement of the mercury from the compartments in which the sodium chloride is decomposed and sodium amalgam is formed into the other compartments in which the sodium amalgam is decomposed and sodium hydrate formed. The apparatus is shown in Fig. 4, the upper diagram being a horizontal section and the lower diagram a vertical section along the line 11. The vessel *A* is divided into four compartments, I, II, III, and IV. In the bottom of the receptacle *A* four grooves *F*, F^1, F^2, F^3 are provided, into which the partitions *C*, C^1, C^2, C^3 are so inserted that they do not engage the bottom of the grooves. Four slots are thus provided, which form traps between the different compartments but allow the passage of the mercury. The electrolysis of the alkaline-chloride is effected in the cells *I* and *II* and the amalgam formed therein at the cathode is decomposed by water in the cells *III* and *IV* and alkaline hydrate generated. The bottom of the receptacle *A* is covered with mercury which also fills the grooves *F* beneath the partitions *C*, C^1, C^2, C^3. During the electrolytic action the whole layer of mercury must be uniformly moved through all the compartments in order to convey the amalgam formed in the compartments *I* and *II* into the compartments *III* and *IV* for decomposition, as well as to return the regenerated mercury from the compartments *III* and *IV* to the amalgamating or electrolytic compartments *I* and *II*. This movement of the mercury is attained by providing the compartments or cells *III* and *IV* with cavities *D*, D^1, in which fluted drums *E*, E^1 revolve, their ribs *H* uniformly propelling the mercury in the cavities *D*. The drums are driven in opposite directions by means of pulleys *G*, G^1. (1,009,061, Nov. 21, 1911.)

Mercury Cathode Cell.—A patent by Mr. Henry Croston, of New York City, describes details of a mercury cathode cell, the feature being the method of moving the sodium amalgam formed, so as to provide always a fresh mercury surface for the cathodic action. For this purpose scrapers are arranged, which reciprocate horizontally in the tank, in a longitudinal direction. (1,009,133, Nov. 21, 1911, assigned to General Chemical Company.)

Electrolytic Production of Oxygen and Hydrogen.—The electrolytic cell of A. Tommasini, of New York City, as shown in Fig. 5, contains vertical anodes 6 and cathodes in form of inverted U-shaped receptacles 5. The outside of these receptacles 5 is completely covered with an insulating cover 7 which extends to a point above the liquid line, and to a point below the lower edge of the cathode 5 proper, so that an overhanging apron 8 is provided. The oxygen is evolved at the plates 6 and accumulates in the space in top of receptacle 4, while the hydrogen accumulates in the top of the inverted receptacles 5 and is conducted off through the pipe 12 and the pipe 11 into the safety device 14. The head of water is less in the safety device 14 than in the receptacles 5, so that when the pressure of the hydrogen gas becomes so great as to tend to press the fluid out of the chambers 5 (which would result in the mixing of the hydrogen with the oxygen) the pressure of the hydrogen gas will first press the water out of the receptacle 19 and pass out of slots 20, so as to relieve the pressure in the receptacles 5. The aprons 8 at the bottom of the compartments 5 also prevent mixing of the two gases. (1,035,060, Aug. 6, 1912.)

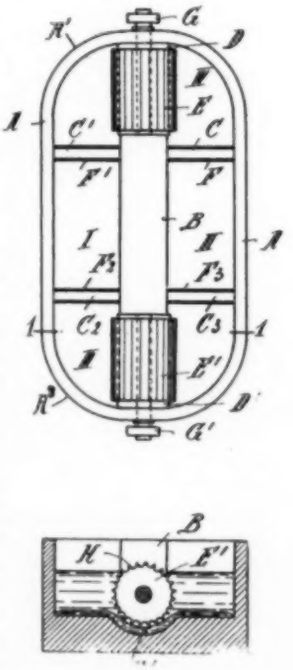


FIG. 4.—MERCURY CATHODE CELL.

Pickling Aluminium Before Plating.—A process of pickling aluminium prior to galvanizing or coating with other metals is patented by Mr. Stephan Jahn, of Charlottenburg, Germany. The aluminium to be coated is first cleaned and freed from grease. After this it is inserted into a heated bath "containing diluted acid of the halogen group with the addition of

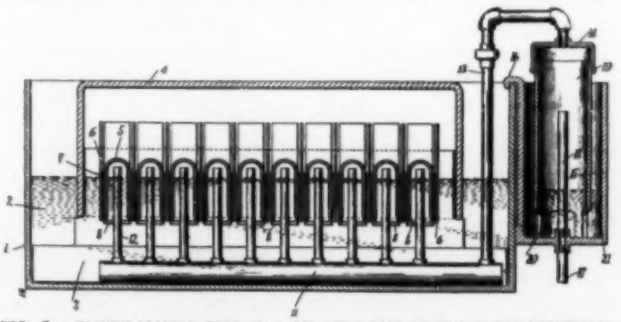


FIG. 5.—ELECTROLYTIC CELL FOR OXYGEN AND HYDROGEN PRODUCTION.

restraining agents." The latter serve to restrain or check the reaction so as to prevent the aluminium from being too readily attacked. Examples of bath compositions are: 500 grams hydrochloric acid, 1000 grams water, 150 grams ethyl alcohol, at 70 deg. C. (the ethyl alcohol being the restraining agent); or 10 grams hydrofluoric acid in 1000 grams water and 15 grams ethyl alcohol at 70 deg. C.; or 500 grams hydrochloric acid with 150 grams glycerine or with 30 grams of citric acid at 70 deg. C.; or 10 grams hydrofluoric acid with 15 grams glycerine or with 20 grams of citric acid at 70 deg. C.; or 200 grams of hydrochloric acid with 1000 grams of water at 40 deg. C. (1,011,203, Dec. 12, 1911.)

Iron and Steel.

Electric Steel Refining.—Mr. WILLIAM R. WALKER, of the U. S. Steel Corporation, claims the recarburiding of steel prior to transferring the metal to the electric furnace. Blown Bessemer metal, low in carbon, is sometimes transferred quite a distance to the electric furnace. A considerable amount of metal will solidify and form skulls in the transfer ladle. These skulls varying in amount will render the charge to the electric furnace variable. By raising the carbon content of the metal its melting point is lowered and hence the amount of skulling prevented or greatly lessened. (The reviewer might call attention to the fact that the text of the patent contains a mistake which reverses the sense of the explanation by saying "I raise the carbon and thus also its melting point.") Molten pig metal is blown in a Bessemer converter until the silicon is eliminated and the carbon reduced to a definite percentage, preferably to about 0.05 per cent. This can easily be gaged from the "drop" of the flame. The carbon is then raised to about 0.3 per cent as a rule, the best percentage of carbon being governed somewhat by the time during which the metal is to be held in the ladle before pouring into the electric furnace. The carbon may be added into the ladle in the form of anthracite, powdered coke or pig iron, preferably molten pig. The metal thus enriched in carbon with substantial precision is then charged into an electrically heated furnace, treated preferably with basic additions for removal of sulphur and phosphorus and brought into proper condition for casting into ingot molds. (1,014,425, Jan. 9, 1912.)

Pure Iron.—Mr. ARTHUR P. SCOTT, of Brackenridge, Pa., gives as one of the objects of his invention the preparation of an iron which is practically free from occluded slag particles and oxides. As the microscope discloses, these impregnate all iron heretofore produced to a greater or less extent. When removing carbon and manganese under a basic slag below a certain limit the iron takes up oxygen in the form of oxides and nitrogen. The inventor therefore melts down in an open hearth or electric furnace or in any combination of the two a charge of pig and scrap in the usual way, removing the ordinary impurities until the carbon has reached 0.20 per cent or any other point in any individual case just before the iron commences to suffer oxidation. He then adds an oxidizable agent such as titanium or ferro-titanium and by continuous injection of it protects the iron from oxidation and continues to oxidize the carbon to a point not over 0.10 per cent to 0.15 per cent. Forcing sticks of wood below the metallic bath helps to combine the smaller occluded particles of slag with the larger bodies and to bring practically all of the slag to the top. The ingots thus obtained are said to be practically free from blow holes and have little or no piping. The metal is highly malleable and ductile and by reason of its fineness is particularly receptive to metal coatings of any kind. (The reviewer considers 0.904 per centum of nitrogen as a printer's mistake.) (1,017,473, Feb. 13, 1912.)

Denitrogenizing Practically Pure Iron.—Nitrogen is the most noxious known impurity in iron. It is deleterious in amounts exceeding 0.007 per cent, causes brittleness, and makes the iron unreliable. Mr. ROBERT D. CAMPBELL, of Pittsburgh, Pa., describes a method to eliminate nitrogen with the aid of titanium or any of its alloys either completely or at all events to at least 0.004 per cent. He uses the improved open hearth or the electric furnace or any other methods or form of apparatus to melt and treat the iron. He has found that the common practice to use the ferro-titanium in a cold state is not necessary to be observed, that it is not safe, however, to preheat the alloy above 500 deg. C. He therefore keeps within this maximum and preheats the ferro-titanium. While in former processes using this element the metal never had a higher temperature than about 1575 deg. the denitrogenizing and deoxidizing effect of titanium becomes most effective at a heat between 1575 and 1700 deg. C. The amount of titanium used may be such as to pass off with the slag entirely or to provide for any desired percentage in the product. The inventor is able to produce pure iron containing in the aggregate not more than 0.10 per cent of C, Mn, Si, S and T and not exceeding 0.04 of oxygen and occluded slag. The qualities of the product are described as practically the same as in U. S. P. 1,017,473, abstracted above. (1,017,620, Feb. 13, 1912.)

Steel for Electric Purposes.—WALTER RÜBEL has found that manganese, silicon and phosphorus reduce very strongly the usefulness of iron for electrical purposes where this iron is subjected to alternating magnetization. Hysteresis and electric conductivity should be kept low so as to reduce the magnetic losses and the eddy currents. Slight contaminations through sulphur and carbon are less injurious. To obtain a satisfactory iron for dynamo sheets the inventor therefore removes the manganese silicon and phosphorus as completely as possible. He furthermore improves the quality of such iron which has been perfectly freed from injurious contaminations by the addition of 1 per cent of copper, which for certain purposes may be increased up to 3 per cent. To obtain the said purification of pig iron the author wants to use the basic Bessemer (Thomas) and the acid Bessemer process in rotation or reverse the order. He also admits electrical or Siemens furnaces suitable for carrying into effect the acid and the basic process. The addition of spiegeleisen must be entirely avoided and copper serves as deoxidizer. (U. S. P. 1,033,352, July 23, 1912.)

Manufacturing Steel.—Mr. HENRY D. HIBBARD, of Plainfield, N. J., divides the elimination of impurities from molten iron into two stages, the exothermic and the endothermic parts of the process. He needs two to three vessels to carry out the following process: Oxide of iron is heated or melted in No. 1 vessel; it can be dispensed with when the iron which is going to act on this oxide contains enough silicon to furnish a sufficient amount of heat by its own combustion to melt the oxide of iron. No. 2 is a closed reaction vessel in which most of the silicon is oxidized by exothermic reaction of pig iron on oxide of iron. The vessel is preheated to red or white heat respectively. No. 3 is a furnace of the open hearth type heated by fuel, electricity or any other suitable means. After finishing the reaction in No. 2 furnace the metal is transferred to No. 3 and the carbon oxidized endothermically by new additions of oxide of iron. Seven claims cover the variation of temperatures, vessels, application of heat and order of rotation of processes. (1,035,120, Aug. 6, 1912.)

Treatment of Iron Ores.—Mr. BIRGER FJELD HALVORSEN, of Christiania, makes use of a process similar to "pyritic smelting," in which the sulphur of one substance forms SO_2 with the oxide from another and produces a pure metal besides. In order to have SO_2 in such concentration that it can commercially be used for other purposes he subjects rich iron ores, preferably those which have been dressed by magnetic separation, to the smelting in an electric furnace. By removing the gangue prior to smelting and avoiding any fluxing material, he reduces the slag formed to a minimum and obtains a rich sulphur dioxide gas. The oxidic ore has to be used in excess. After all the sulphur has been expelled the refining is accomplished by adding fluxing material and lime and finishing the

metal in the usual way. High grade iron—nickel ore are specially fitted for this treatment. (1,024,629, April 30, 1912.)

Method of Treating Steel.—The title of this patent is somewhat misleading as it does not deal with the thermal treatment of steel, but with a certain phase of the manufacture. The wearing and shock resisting qualities of steel are oftentimes improved by lowering the amount of carbon and correspondingly increasing the manganese. The inventor, Mr. Auguste J. Rossi, the distinguished pioneer of titanium, has found that he can obtain a better product by keeping the manganese in low limits, above 0.18 per cent and not over 0.60 per cent, and raise the carbon to heretofore unusual amounts. This is made possible by adding ferro-titanium in such amounts that the titanium in the product is less than 1 per cent and not enough to designate it as an alloyed steel. The titanium is supposed to combine with undesired elements and compounds and to insure their removal together with the slag. As an example he states that when adding from ⅔ per cent to 1½ per cent of a ferro-titanium containing 10 per cent to 12 per cent titanium to a 0.85 per cent carbon rail steel the steel rolled perfectly and the resulting rails showed qualities of endurance and of resistance to vibration hitherto unattained and otherwise unattainable. (1,028,389, June 4, 1912.)

Steel Metal.—Mr. Auguste J. Rossi adds a new divisional application to a former patent covering the use of titanium in steel making. The main feature of the inventor's claims is that manganese and silicon should be practically eliminated before the addition of titanium is made and that titanium produces such properties in the steel that these elements can be entirely dispensed with. While in common practice steel without 0.4 to 1 per cent of manganese is considered as unfit for rails and other purposes, the proper amount of titanium now takes care of the deoxidation as well as of imparting to the finished product the physical properties required. The metal can be produced by any of the well-known smelting and refining processes with the only exception that the recarburization has to be accomplished with other substances than spiegeleisen or ferromanganese. The silicon in the finished product ought not to exceed 0.02 per cent, the manganese not to exceed 0.2 per cent, and the titanium to remain below 2 per cent. The inventor is aware of the fact that aluminium containing from 0.75 to 2.50 per cent of titanium, when added to the steel, does not accomplish the same effect as his invention, as it does not bring enough titanium into the bath and as he dispenses with the use of aluminium altogether. Otherwise the amount of titanium used in his process and remaining in the steel is not sufficient to warrant the designation of his product as an alloy steel and he does not want to call it titanium steel. (1,029,637, June 18, 1912.)

Producing Metallic Iron and Alkaline Salts.—A patent has been granted to Mr. Edwin C. Eckel for smelting glauconite, a hydrated silicate of iron and potassium, in such a way as to reduce the iron and to volatilize the potassium salt. The potassium will be recovered in a dust-catcher, usually in the form of carbonate. The large deposits of glauconite, as the patent claims, are largely unused. (They could, however, be used for agricultural purposes). The average composition of the mineral is about 50 per cent silica, 30 per cent ironoxide, 6 per cent potassium, some phosphorus and 10 per cent water. Considered as an iron ore this would hardly be worth while touching; the simultaneous production of a potassium salt, however, should make it pay. The mineral is mixed with limestone and coke, f.-i. 10 tons of glauconite, 7½ tons of limestone and 5 tons of coal. This will produce slightly over 2 tons of pig iron and considerably over 1 ton of potassium carbonate. The slag will have the approximate composition, 53 per cent silica, 3 per cent alumina and 44 per cent lime and will be serviceable as raw material in several industries. (1,011,173, Dec. 12, 1911.)

Refining Iron and Steel.—Mr. Karl Fredrik Hiorth claims the regeneration of slag which has been used for dephosphorizing steel from, for instance, 0.06 per cent P. to 0.008 per cent P. The iron thus practically free of phosphorus is poured into a ladle either completely or by leaving a small amount of metal under the slag. In the first mentioned case some cheap iron may be charged into the furnace and in both cases carbon is used to reduce the phosphorus from the slag into the metal. The latter would then be a valuable product f.-i., for the basic Bessemer furnace. After pouring it off the purified metal could be returned to the furnace, could be deoxidized, alloyed, etc., and finished in the desired way. Instead of keeping the metal in the ladle during the regeneration of the slag it could also be charged into a second furnace and finished therein. Other valuable substances such as chromium, manganese, molybdenum, vanadium, wolfram and the like, which are taken up by the slag during dephosphorization of the metal, could be recovered in a similar way, separately or by groups, by carrying the treatment of the slag out fractionally. (1,028,070, May 28, 1912.)

Composition of Matter.—Mr. Robert M. Corban claims that his welding compound consisting of 75 per cent SiO_2, 15 per cent Al_2O_3, 2 per cent CaO and 8 per cent K_2O and Na_2O, will reconvert oxide of iron to a metallic state, when iron or steel have been "burnt" in forging and welding. To prepare the flux for use the ingredients are reduced to finely granular and preferably powdered form and thoroughly mixed. The "inventor" has found that above proportions admit of a considerable range of variation without affecting the results. (U. S. P. 1,034,979, Aug. 6, 1912.)

Reversing Valve for Regenerative Furnaces.—Mr. Hugo Gille has invented a new reversing valve of the bell type of light construction. It is characterized by a circular trough with sealing liquid and two transverse troughs forming a cross within this circle. They form four sector-shaped apertures, each of which in one position has to be connected to its neighbor at the left, after reversing to its neighbor at the right. Consequently the bell has one diametrical partition. This is built as a channel open to the atmosphere at the top and at both ends; it thus picks up sealing liquid each time it is dipped into one of the transverse troughs. Partition and liquid are thus efficiently cooled. The bell is suspended from a support by rods which receive a compulsory movement to turn the bell 90 per cent whenever the lifting mechanism is actuated. The lifting mechanism is described in detailed drawings. It consists either of a screw shaft driven by gear and pinion from an electromotor; a rider on this screw lifts the bell support by means of levers, or a hydraulic plunger which is forced alternately into two cylinders and which carries a block fixed to its center. This block performs the same duty as the rider on the screw shaft. (1,033,577, July 23, 1912.)

Charging Furnaces.—In modern blast furnace practice the material is delivered to the top of the furnace in skip cars and successive skip loads are dumped at the same side of the furnace. This produces an uneven distribution of material in the furnace as the coarser and heavier particles will go into the hopper on the side opposite the dumping, while most of the finer particles will dribble down more slowly into the near side of the hopper. Consequently the passage of the gases will be ununiform and the working of the furnace irregular. Mr. Frank C. Roberts provides two different means to overcome the evil effect of this segregation. He describes a charging device in which the receiving hopper is continuously rotated while receiving material from the skip or while unloading this material into a second hopper of the bell type, or in both instances. In the second charging hopper may or may not be assembled a plurality of skip loads before introducing them into the furnace. The second way to accomplish the purpose is the use of a rotary mixing chute through which the skip loads pass into the hopper. The mixing chute contains a diaphragm, and by rapid rotation the coarse and fine materials which strike the diaphragm are mixed and uniformly distributed in the hopper.

For details see the drawings in the original. (1,033,036, July 16, 1912.)

Dry Cleaner for Gas.—If a body of gas be given a vortex or spiral movement around an axis in a closed vessel, the dust and other impurities will tend, under the influence of centrifugal force, to move to the periphery of the moving body. If then means be provided to skim from the vessel the outer stratum of gas, the dust which is centrifugally concentrated there will be driven off from the body of gas in the vessel. Electrical means may be used, also, to agglomerate the fine dust into larger particles which will respond more readily to the effect of centrifugal force and gravity. This is the principle on which MARK W. JOHNSON, JR., of Birmingham, Ala., has devised a dry cleaner for furnace gases. With reference to Figs. 6 and 7, which illustrate the invention, 1 represents the central annular jet through which the gas to be cleaned is passed to the ring nozzle 3. On its way thither, the gas first passes an

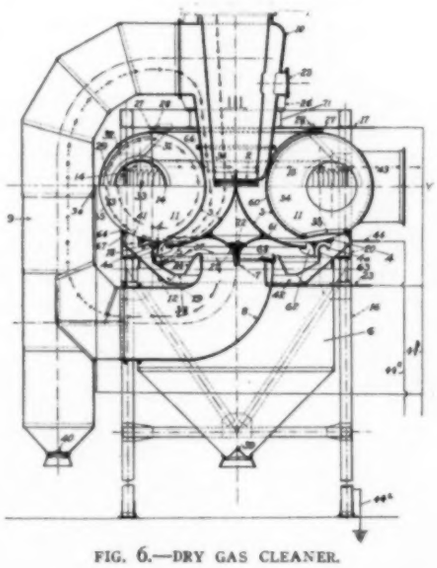


FIG. 6.—DRY GAS CLEANER.

electrode 2, consisting of a copper bar carrying numerous fine points extending downward, where the particles of dust become polarized by induction and agglomerated by electrical attraction. Passing the electrode, the particles are thrown against the lower curved surface of the ring nozzle 3. Part of the gas containing the most dust, is then caught under the knife edge of the dividing ring 4 and turned downward, striking the first deflector ring 5, passing thence into the ring port 37 into the circulation elbow 8. The practically static body of gas in the dust chamber 6 will exert a back pressure on the stratum of gas deflected by the knife edge against the ring 5, which back pressure will have a tendency to increase the deflection of the lighter and cleaner gas of the stratum toward the ring port 37. The cinder and dust will, however, pass along the plate 5 into the dust chamber, while the dirtier gas will tend to form eddy currents which pass off through the port 37. From the deflector 5; the dust which is separated will pass into the dust chamber through the port 38.

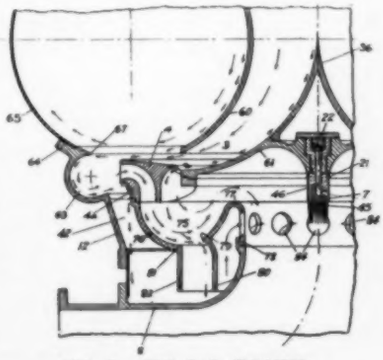


FIG. 7.—DRY GAS CLEANER.

As the gas enters the circulation elbow 8, it passes the second electrode 7, where any remaining dust is agglomerated as before. On its passage through the elbow it is thrown downward and caught in the lower end of the circulation pipe 9. The circulating gas will then again pass the electrode 2, and any remaining dust particles are thrown out and combined with the dust from gas entering through the nozzle 1. The gas now passes through the ring nozzle 3 as before, but is now in an upper stratum which escapes the knife edge and passes into the vortex chamber 11, where it begins to circulate rapidly in the form of a vortex spiral. In each revolution it passes the third electrode 13 where dust is agglomerated and thrown against the outer shell of the vortex chamber. Here it is swept around until it reaches the ring port 41 into which it is deflected by the edge 67, and through which they enter and are swept along until they enter the dust chamber by port 42. The cleaned gas will pass out of the vortex chamber through the ring 14, where it is turned by vanes 33 to the discharge chamber 15 and then through the outlet 43 to the gas main. By this process the inventor claims to clean gas without the use of sprays. (1,024,784, April 30, 1912.)

Cleaning Device for Water-Cooled-Wall Furnaces.—GEORGE J. RENNIE has invented a cleaning device for the narrow water troughs which encircle the blast furnaces of this thin-wall type. The water must flow slowly and at a certain speed through these troughs, and its temperature must not go below a certain limit, as it otherwise carries an uneconomical amount of heat away from the furnace. A heavy stirring of the water by quick circulation must therefore be avoided. The inventor uses a system of piping attached to the furnace structure and connected to a steam injector. At suitable places a flexible hose can be connected to the piping system, introduced into the bottom of the trough, and carry the mud off by suction. The trough can, therefore, be made deeper and narrower than in the former case, where laborious working with long handled spoons and shovels was necessary. (1,035,050, Aug. 6, 1912.)

Gold and Silver.

Treating Gold-Bearing Clay.—It is well known that difficulty is experienced in recovering gold from sticky clays. In order to obviate the trouble, and render the clay more amenable to treatment, JACOBUS VAN DER TOORN, of The Hague, Netherlands, proposes to knead the clay into a coherent mass and then heat it in kilns until it forms a hard stone-like clinker. It is claimed that this treatment at a high temperature changes the clay so that it does not again become sticky when crushed and ground in water, and the gold may be recovered in any desired manner. (1,033,359, July 23, 1912.)

Lead, Copper and Zinc.

Baghouse.—The use of the baghouse for collecting fume from lead smelters is well known. Formerly the bags were shaken by hand, but more recently mechanical means have been contrived to perform this unpleasant work. ALBERT J. MEIER, of Glendale, Mo., has patented means for mechanically shaking the bags in any section of a baghouse, and automatically cutting off the flow of fume from that section while the bags are being shaken. In Fig. 8, which is a vertical section of part of a baghouse, shows the invention. Referring to the drawing, *A* represents the bag chamber, containing bags 17, suspended from their closed ends at the rod 18, and fitting over thimbles in the floor between the bag chamber and cellar *B*. The flue through which the fume is led to the baghouse is designated at *G*. Leading from this flue are smaller flues *b* connecting with each division of the cellar.

The bars 18 are provided at one of their ends with rolls 22 adapted to be engaged by cams 23 on an operating shaft 24. This shaft extends across the building and is driven at a slow speed in a clock-wise direction from a suitable motor, not shown. By this mechanism, the bars 18 will be shaken lengthwise against the tension of the springs 20, which support them, and the accumulation in the bags will be dislodged and caused to fall into the cellar.

While the bags of a division are being shaken it is necessary that the flow of fume be cut off from that division. In order to accomplish this automatically, a damper cam 31 is placed on the shaft 24, which operates a lever 30 and 30a supported at 29. The outer arm of the lever is connected with an endless cable passing over pulleys as shown, and connected with a sliding rod 33 of the damper 34 controlling the port *b*. Normally the damper is kept open by the weight 35, but when the damper cam 31 engages the lever, the cable operates the damper so that it is closed while the bags are being shaken. After the shaking operation is completed, the damper is released and returned to its open position. This construction can be extended to operate as many divisionse of a baghouse as desired, and the arrangement of cams on the shaft can be such that the different divisions will be shaken successively. (1,030,477, June 25, 1912.)

Copper Castings Free from Blow Holes.—At the Chicago meeting of the American Electrochemical Society, October, 1910, Dr. E. Weintraub, of the General Electric Company, presented the results of his efforts to produce copper castings free from activities. An abstract of his paper was published in

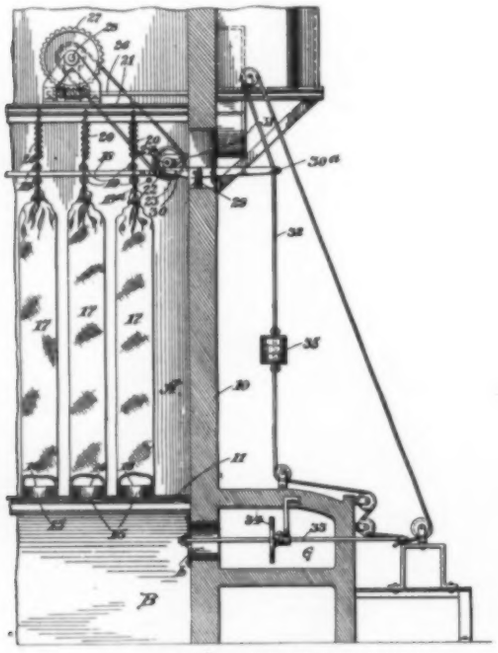


FIG. 8.—BAGHOUSE.

this journal, November, 1910, page 629. Recently Dr. Weintraub has procured United States patent on his method of improving copper castings, as outlined by him in 1910. Essentially the process consists in adding to molten copper of ordinary chemical purity a small quantity of boron, varying from 1/30 of 1 per cent to 1/10 of 1 per cent. This may be added in the form of a boron compound, such as a suboxide or carbide. Copper castings made from copper thus treated contain no cavities and show an electrical conductivity as high as 95 to 98 per cent, according to the Matthiessen standard.

As a convenient method of applying the invention, the boron material is placed in the bottom of a crucible mixed with pure charcoal, and then covered with the copper to be treated. During the process the deleterious gases are removed from the copper by the boron. The copper is not injured by an excess of boron, as it does not combine with the copper, but either oxidizes and collects as a slag or remains mechanically mixed in the copper.

While the method is described as being applicable in the foundry, it is to be understood that it is equally valuable in the smelting process, and can replace the process of "poling" now universally as the first step of refining copper as it comes from the converters. Poling is a rather crude and uncertain process, and the resulting copper has not a high conductivity. The boron method is more exact and can be applied to the manufacture of casting copper in the smelting operation.

Incidentally it may be mentioned that silver is similarly affected by the addition of a boron compound, and castings of that metal may thereby be greatly improved. (1,023,604, April 16, 1912.)

Coating Iron Articles with a Zinc Alloy.—A new process of providing iron articles with a protective coating, consisting chiefly of zinc, and resembling in some phases the well-known sherardizing process, has been patented by Prof. Charles F. Burgess, of the University of Wisconsin. The chief new feature is the alloy which is used for coating. For this purpose zinc dross, such as obtained as a waste product of the hot galvanizing process and consisting essentially of 97 and 93 per cent zinc and 3 to 7 per cent iron is used. This is crushed and placed into a rotary iron drum together with chunks of pure iron, such as wrought iron or electrolytic iron, and heated to about 850 deg. Fahr. In this way a saturated solution of iron in zinc is obtained with the composition of about $FeZn_{10}$. This is exceedingly brittle and easily brought into a granular condition. The iron article to be coated is then placed, together with this granular alloy, into a close drum, which may be rotated, and is heated as in sherardizing. Heating for two hours and to a maximum temperature of 700 deg. to 800 deg. Fahr. gives good results. For some purposes it is preferable to mix the $FeZn_{10}$ with about 5 per cent zinc. The advantage of this alloy is that it is exceedingly brittle, and, therefore, easily ground up in a rotating drum, that it is non-explosive and that it is not fused or sintered into a coherent mass, even when heated to 1300 deg. Fahr.; in this respect it is quite different from zinc dust. (1,014,946, 1,014,749 and 1,014,750, all assigned to the United States Sherardizing Company of New Castle, Pa., and 1,014,751, all of Jan. 16, 1912.)

Metallurgy of Zinc.—Improvements in the metallurgy of zinc have been proposed recently by F. L. Clerc, of Boulder, Colo. The first patent which was granted on his proposed copper-bottom furnace, was reviewed in this journal, November, 1911, page 609. More recently Mr. Clerc has presented his ideas more fully in articles printed in Metallurgical and Chemical Engineering, July and August, 1912, pages 399 and 463. We note an additional patent bearing on this subject, covering the ideas advanced in the article last mentioned. (1,012,816, Dec. 26, 1911.)

Aluminium, Magnesium, Nickel.

Aluminum Solders.—A new composition of matter has been patented by Charles R. Erkens, of New York City, and assigned to the Simplex Aluminium Solder Company, of New York City. The object of the invention is to provide a solder which will be useful in uniting pieces of aluminium without preheating the parts to be soldered, and which can be applied by an ordinary soldering iron. The composition contains 60 parts block tin, 15 of zinc, 10 of lead, and 5 each of antimony, bismuth and chromium; total, 100 parts. After melting and mixing these metals, the alloy is cleansed while molten by adding 35 grams of salicylic acid and 10 grams of calcium to each 5 lb. of alloy. As a suitable binding agent for impurities which form a slag to be skimmed from the alloy, 2 drams (17.72 grams) of sulphur is added. About 5 per cent of the oxidizing and cleansing agents will be retained in the alloy and will serve to take the place of the flux ordinarily used in soldering. (1,033,565, July 23, 1912.)

Preparation of Nickel for Catalyzing Purposes.—Finely divided nickel as prepared for catalyzers possesses pyrophoric properties which render the substance unsuited for indiscriminate use in air. Edwin C. Kayser, of Cincinnati, O., has devised a process for rendering finely divided nickel non-pyro-

phoric and stable. The patent has been assigned to the Procter & Gamble Company, of the same place. The feature of the invention consists in reducing a nickel compound in a current of hydrogen in the usual manner, and then passing carbon dioxide over the reduced nickel, while still hot, and continuing to pass it thus until the escaping gas is no longer inflammable. The nickel is then allowed to cool in an atmosphere of carbon dioxide, whereupon the resulting product is found to have lost its pyrophoric tendencies, and remains stable in the air for days. (1,001,279, Aug. 22, 1911.)

Purification of Clays.

Preparation of Fullers' Earth.—The removal of the deleterious mineral and organic materials from fullers' earth is a necessary step in the preparation of a product suitable for commercial purposes. CHARLES C. RUPRECHT, of Blakely, Ala., proposes to use the electric current in purifying and precipitating fullers' earth from suspension in water. Referring to Fig. 9, a mixing tank is shown at *A*, where the earth is mixed with water and formed into a "slip." From the mixer the slip passes by spout 4 to a series of settling vats *B*, *C*, *D*, arranged in cascade. In these vats, which are 30 ft. by 3 ft. by 3 ft., the sand is allowed to settle from the slip, which then passes on to the electrical treatment vat *E* where the purification of the clay from organic matter is accomplished. A plan view of the

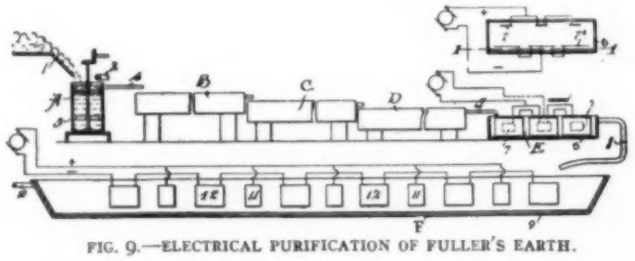


FIG. 9.—ELECTRICAL PURIFICATION OF FULLER'S EARTH.

arrangement of this vat is shown in upper right hand corner of the figure. Its dimensions are 16 ft. long by 3 ft. square. Three anodes of carbon, each 16 in. square, are suspended along one wall of the vat, and three cathodes of copper, each 3 ft. by 4 ft., are similarly suspended on the opposite side, spaced 2 ft. from the anodes. Between these electrodes the slip passes, at a fairly rapid rate of flow to prevent too great precipitation in the vat. To increase the conductivity of the electrolyte, some sodium chloride or sulphuric acid may be added.

The resulting electrolysis has the effect, in case salt is added, of forming chlorine products, some of which remain with the clay, and subsequently improve its bleaching quality. If acid is used, it has the effect of destroying organic matter. The current used is about 150 amp at 110 volts. A sufficient current-density is about 1/5 amp per sq. in. of positive electrode surface.

From the vat *E*, the slip flows into the larger electrolytic vat *F*, where the velocity of flow is greatly reduced, and where the electric current effects a precipitation, or settling, of the earth. This vat may be 80 ft. long, 60 ft. wide and 5 ft. deep. Electrodes are arranged along the sides, the carbon anodes on one side being placed between the spaces between the copper cathodes on the other. An anode surface of 100 sq. ft. and a cathode surface of 150 sq. ft., with current at 110 volts, gives good results. In this vat the earth is precipitated and allowed to accumulate until it becomes necessary to clean the tank. The accumulation is dense and readily treated for the removal of contained water. (1,024,104, April 23, 1912.)

Sinter-Roasting and Agglomerating.

Process of Agglomerating Finely Divided Mineral Substances.—Recent developments in sinter-roasting fine ores, flue dust, etc., in pots or on chain-grates, have employed the principle of kindling one surface of the mass, and then propagating the combustion through it by blowing or drawing air from the kindled to the unkindled side. In patents granted to FREDERICK W. YOST, of Chicago, Ill., he discloses his idea of reversing the direction of the air blast, passing it from the unkindled to the kindled surface. By this procedure he claims that the products of combustion do not contaminate the zone of reaction as in the other type of roasting, and that the reaction is susceptible of more perfect control than is possible in the other method. Further, that the operation can be conducted in two stages; a heating and roasting operation propagated in one direction, and a clinkering action subsequently propagated in the opposite direction. The process is adapted to any of the types of roasters now known and used, and may be applied to the roasting of sulphide ores, agglomerating iron ores with added combustible matter, clinkering cement materials, etc. The patent specifications are voluminus, and contain from 35 to 40 claims each. (1,003,682-3-4, Sept. 19, 1911.)

Synopsis of Metallurgical and Chemical Literature.

Gold and Silver.

Solubility in Nitric Acid of Gold Contained in Copper Bullion.—Up to a very recent date gold has been held to be insoluble in pure nitric acid. Attention has been called, however, to the discrepancies existing between the all-fire and the acid-fire, or combination method assaying gold in copper bullion. More recently, F. P. Dewey has demonstrated that pure gold dissolves in small quantity, on long continued boiling, in pure nitric acid. In the *Bulletin* of the American Institute of Mining Engineers, July, 1912, DR. EDWARD KELLER takes up the subject and gives results of his observations on the solubility in nitric acid of gold contained in certain copper bullions.

Copper bullion usually is cast in comparatively thick pigs, or ingots, and thin slabs, or plates. Sampling is done by drilling according to templates. The drillings are ground to pass a 16 or 20-mesh screen, and, in the author's practice, the final sample is further divided into fine and coarse portions by passing through a 40-mesh screen. The fine part will contain foreign matter, oxides, slags and mold-wash, while the coarse will be clean metallic particles. Assays of the fine and coarse parts show the necessity of separate assays of the two, and the averaging of results according to their ratio.

Experience shows that the all-fire assay is the most accurate attainable, when slag and absorption losses are accounted for. In the nitric acid combination method, the conditions are variable, and varying quantities of gold are dissolved and lost. In the tests made by the author, the wet combination method was carried out as follows: One A. T. of copper was dissolved in 190 cc. distilled water and 90 cc. nitric acid (1.42 sp. gr.). The reaction was completed at a temperature of about 160 deg. F., after the first violent reaction was over. When all red fumes had disappeared, the solution was filtered on a triple S. & S., No. 597, 12.5 cm. filter covered with 2 g. test-lead. After incineration of the filter, and the addition of 20 g. test-lead, a sufficient quantity of silver, in the form of nitrate crystals, was added. From this point the assay was conducted according to the well-known fire method.

Inasmuch as the deficiencies of the fire treatment apply to both the all-fire and the combination methods, if we now determine the gold by the all-fire method and by the combination method, the difference should be equal to the loss by solution in the combination method.

The author's serious attention was first attracted to the solubility of gold in nitric acid by peculiar facts connected with the assay of two samples of bullion which were the same in origin, composition and metallurgical treament. Samples representing many million pounds of copper were assayed for gold by the all-fire and combination methods, with the result that, for bullion No. 1, the gold yield by the combination method showed a deficit of 13.71 per cent, as compared with the all-fire method.

while for bullion No. 2 the corresponding figure was 26.62 per cent. These figures may be regarded as denoting the solubility losses in the two bullions, but it is to be noted that the loss in one is nearly twice that in the other.

The only difference between these two bullions was that No. 1 was cast in 300-lb. pieces and No. 2 in 500-lb. This fact implied a difference in the rate of cooling, and led to the conclusion that gold in slowly-cooled copper bullion is more soluble in nitric acid than that contained in rapidly chilled copper. There was ample evidence that the gold solubility was not influenced by any mechanical differences in the samples. The conclusion was confirmed by noting that the solubility of the gold could be reduced to a minimum by instantaneously chilling a sample of bullion.

Synthetic experiments were made to determine the influence of increasing either the gold content or the impurity content of the bullion, but neither appeared to augment the quantity of soluble gold. In conclusion the author finds that: Gold contained in copper alloys or bullion is soluble in nitric acid in varying degrees; that the solubility diminishes with the rate of cooling, but that even quenched samples show soluble gold. The maximum of the deficit in gold recovered by the combination assay, as compared with the all-fire assay, is approximately 2 per cent. The highest amount of soluble gold was found to be 0.0017 per cent of the total bullion, and no increase in the gold or impurity content of the bullion was able to augment that amount. The author further calls attention to the trouble that may arise among assayers, on account of difference in the methods of sampling copper bullion. One assayer may have a shot sample, quickly quenched, while others may have samples from castings which have been slowly or quickly cooled. If assays are made by the combination method, the variation in the amount of soluble gold will give rise to apparently unaccountable differences.

Abrasion and Dust Losses in Ore Drying.—In preparing ore for dry treatment processes, such as magnetic separation, dry concentration, etc., it is customary to pass the crushed ore through a rotary drier or drop it down a shaft in which its progress is interrupted by baffles. In either case, a stream of hot gas flows in the opposite direction to the flow of ore. Loss of mineral by abrasion and dusting is one of the objectionable features of these processes, and unless provision is made to collect the dust, serious loss may result. In the *Bulletin* of the American Institute of Mining Engineers, July, 1912, Messrs. C. F. Dietz and D. V. Keedy give some examples of dust losses that have come under their observation, and outline the test of a dust-collecting plant, showing the saving that can be made by suitable apparatus.

In one case, a lead-silver ore crushed to 1½ in. size, was dried in a rotary drier. By taking weights and making assays, it was found that 3.8 per cent by weight of the material introduced into the drier was drawn ou by the draft. This amounted to a loss of 9.3 per cent of the lead content and 4.6 per cent of the silver. At the then prevailing metal prices, 7.6 per cent of the total value of the ore was taken out of the drier by the draft. Some of this was caught in a settling chamber and an additional quantity in the stack, but there was a total loss of 1.85 per cent of the money value of the ore.

In another instance it was found that the drier was acting as a crusher, reducing 12.3 per cent of the ore to sizes finer than existed in the original feed. This abrasion was responsible for heavy dust losses.

For the recovery of dust which is produced by abrasion and carried out of stacks, exhaust fans can be used, connected with a system of flues running to all points in the mill where dust is formed. The collected dust can be blown into a centrifugal dust collector, where it is settled dry, or moistened by steam jets and water sprays. This system can be used with great success, and mills kept free from objectionable dust which, aside from being a source of loss in itself, has an injurious effect on pulleys, bearings and belting.

Cyanidation-Amalgamation.—The metallurgical process used at the high-grade mill of the Nipissing mine, Cobalt district, Ontario, Canada, was specially devised to treat the high-grade silver ore from the mine, and is most interesting. The following details are taken from T. A. Rickard's description in the *Mining Magazine* (London), June, 1912. The ore contains native silver, argentite and arsenides of cobalt and nickel (6 per cent Ni, 7 per cent Co, 40 per cent As). The silver content averages 2600 oz. per ton. The ore is first crushed to 70-mesh and then ground in a tube-mill in charges of the following composition: 3½ tons ore, 4½ tons mercury, and a 5-lb. cyanide solution. Air is introduced to accelerate the reaction, and after 9 hours in the tube mill, 98 per cent of silver has been extracted from the ore, which is then passed to a settler where the amalgam separates by gravity. Clean-up pans and canvas drainers are used to recover the amalgam, and the pulp and solution pass to a vat which supplies a Butters filter. The clarified solution is precipitated in zinc boxes. The solid residue contains the arsenic, nickel and cobalt, and is stored, as there is no satisfactory method for treating it.

The amalgam, 80 per cent mercury and 20 per cent silver, is retorted in 450-lb. lots, and then the silver is melted in a reverberatory for 15 hours. The resulting metal is 999 fine. The furnace flue is equipped with water-jet condensers, whereby from 1000 to 2000 lb. of mercury is recovered monthly.

The process is noteworthy for the amount of mercury which is used, and for the rapidity with which silver is recovered and marketed. It is planned to erect a mill for the similar treatment of the dumps, which contain 80,000 tons of ore assaying 22 oz. silver per ton.

Retreating Rand Tailings.—It is generally claimed that current tailings from Rand cyanide mills contain but ½ dwt. gold per ton, worth about $0.50. Before the improvement in metallurgy, however, the tailings contained from twice to three times this amount of gold, and recent developments make it appear possible to retreat the old dumps and make a profit. In the *Australian Mining Standard*, June 6, 1912, a Johannesburg correspondent gives some details of the proposed method of treatment.

A new form of classifier designed by Prof. G. H. Stanley seems to be the invention about which the new treatment hinges. It is a hydraulic classifier with a screen attached to the fine overflow, with the object of preventing the loss of coarse material of low specific gravity carrying gold, such as usually escapes with slime. Thus the classifier makes three products; a coarse sand, being larger than 60-mesh, a fine sand which is smaller than 60-mesh, and the slime. In fourteen tests on old dump material, containing gold to the value of $1.25 per ton, the average value of the concentrate, or coarse portion, was $1.80; of the fine portion, $0.77. When the concentrate was reground and cyanided by agitation, a minimum extraction of 80 per cent was obtained in 8 hours' treatment. The fine portion gave an extraction of 67 per cent after 6 hours' treatment, and the slime yielded as high as 90 to 95 per cent of its gold. It is considered that an average extraction of 75 per cent can be relied upon, at an estimated cost of 2s. per ton ($0.50).

A company known as Sands Limited has been formed to acquire the rights to the classifier, and has secured options to treat about 15,000,000 tons of tailings. It is estimated that on the Rand alone there is about 70,000,000 tons of tailings that can be treated in this way. A large tonnage will have to be treated daily, say 2500 tons, in order to make a suitable profit.

Copper.

Treatment of Mine-Water.—The water from the Ashio copper mine of the Furukawa Mining Company, Japan, carries about 0.00025 per cent copper, representing more than 18 tons of copper per month. It contains, also, sulphuric acid, ferrous and ferric sulphates, ore-slime and basic iron sulphate. As the water is discharged into the Watarese river, from which water is subsequently taken for agricultural purposes, the mine-water

must be freed from suspended solid matter before being discharged. Several methods of doing this are described by J. W. RICHARDS, in the *Bulletin* of the American Mining Institute, June, 1912.

According to the first method the copper was not recovered. Milk of lime was run into the water and the mixture passed through six settling-ponds, and then through a sand-filter. In the first pond, sand and metallic hydrates settled, free from copper; in the next five ponds, slime, metallic hydrates carrying copper, and calcium hydrate settled. The effluent carried from 0.0001 to 0.00005 per cent copper. The precipitate recovered from the last five ponds contained so much alumina and silica as to be worthless for smelting, and the copper was lost.

In the second method, the water was allowed to run through four of the ponds, to give the soluble sulphates a chance to precipitate the hydrates and thus entrain colloids. The first pond collected sand and slime; the next three contained a precipitate carrying from 0.5 to 1 per cent copper and 70 per cent silica, which was worthless. In the fifth pond, milk of lime was added, producing in this and the sixth pond a deposit of calcium sulphate and metallic hydrates with considerable slime. It carried 4 per cent copper, 22 per cent iron oxide, 20 per cent alumina and more than 30 per cent silica, but was still too poor to smelt for the copper.

In the third method, practically all the copper was saved and the water suitably purified. The water was run through three ponds, in the first of which sand and slime settled; in the second and third, some precipitate of metallic hydrates carrying copper and slime high in silica. In the fourth pond milk of lime was added in small quantity, from 10 to 20 per cent of the whole amount required. This caused a precipitate consisting mostly of hydrated iron oxide free from copper, which also carried down colloidal matter consisting of alumina and silica. In the fifth pond the balance of the lime water was added, completely preciptating the metallic hydrates, which settled in this and the sixth pond. This precipitate was rich enough in copper and low enough in alumina and silica to pay for smelting. It contained from 5 to 6 per cent copper, 12 per cent iron, 6 per cent lime, 4 per cent alumina and 11 per cent silica. This method is now in use, and recovers about 18 tons of copper monthly, giving a clear waste water which is discharged into the river.

Electro-Analysis.

Platinum Electrodes of Light Weight.—On account of the high cost of platinum, various attempts have been made to substitute some other metal or substance for platinum in electro-analysis. Most of these efforts have not yielded satisfactory results, but MESSRS. F. A. GOOCH AND W. L. BURDICK feel that they have made some progress toward reducing the expense of electrodes by reducing the weight. Their experiments are described in the *American Journal of Science*, August, 1912.

Electrodes of platinized glass can be prepared by applying a viscous mixture of glycerine and dry chloroplatinic acid by means of an asbestos swab, the glass being previously raised to a temperature sufficient to volatilize the glycerine immediately. The resulting film of metal is burned into the glass at the softening point of the latter. Experimental results showed that inexpensive electrodes could be made in this way, but the metal film was not permanent and had to be renewed after a few analyses had been performed.

Small electrodes and a weighable cell proved so much better than platinized glass that further experiments with the latter were discontinued. Rotating cathodes of platinum gauze fused to a rod of lead glass proved satisfactory. The gauze was only 1 cm. square, and therefore comparatively inexpensive. On account of the tendency of metallic particles to become detached from the cathode when deposited under high current, this cathode is used in connection with a weighable cell made from the bulb of a thistle-tube, in which detached particles can be retained, washed and weighed.

"Exothermic Steel"

BY WALTER O. AMSLER, D. Sc.

This steel derives its name from its peculiar method of manufacture. It is produced either direct from the ore or from metal already reduced by a heretofore unknown exothermic reaction, under the conditions prevailing in the electric furnace, which to some extent may account for its remarkable properties. The flux used to produce this exothermic reaction is readily obtainable at low prices. No electric current and but comparatively small quantities of flux are required.

This steel was first brought to the writer's attention about a year ago by Mr. George Fogler, the inventor. At that time the claims and descriptions of the process appeared rather absurd and the statements of results were hard to believe. Close investigation of this steel already in use and of the reactions and the theoretical side of the operation led to the conviction that the process has considerable merit.

It was found, for instance, that this steel is in use where it is subjected to the most violent shock, worse than is encountered in ordnance. In this work "exothermic steel" gives from two to five times the service of the best nickel steel forgings.

To demonstrate the extreme exothermic nature of the reaction of this flux on oxides of various metals a quantity of iron ore and flux was mixed in a No. 4 graphite crucible, which was then placed in an ordinary cast-iron "cannon ball" stove and well packed in coal. After about fifty minutes the crucible was removed to find the molten iron separated out under a covering of fluid vitreous slag. After pouring the metal into a chill mold, the fracture indicated a steel of about 150 to 200 carbon. Mill and hammer scale, open-hearth furnace slag and various ores respond in the same way. To prove the extreme heat that may be obtained by this reaction chromium and tungsten were reduced from their oxides and precipitated in the crucible in the same manner and in the same stove. Authorities give the melting point of tungsten at about 3000 deg. C., or about 5400 Fahr. As the tungsten was reduced in the presence of about 50 per cent iron, the temperature was probably lower than the figures given, but still considerably higher than that of the stove.

The process depends upon the exothermic reducing reaction between a metallic oxide and a compound silicate of aluminium by which the formation of aluminium oxide takes place. Other reagents are added to intensify or accelerate the action of the aluminium compound in the flux upon the oxygen in the ore or in the metal bath. The usual reagents are feldspar and bauxite together with a quantity of limestone to make a fluid slag. In practical operation not all the reduction takes place by means of these reagents as the temperature would run too high, so enough carbon is charged to reduce a part of the oxide by formation of carbon oxides to keep the temperature within safe limits.

Feldspar is a compound silicate of aluminium and potassium ($KAl_2Si_3O_8$) and bauxite is a hydroxide of aluminium ($Al_2O(OH)_4$). The reaction breaks up both reagents to form aluminium oxide, Al_2O_3, a vitreous slag and gases. It is necessary to bring the temperature up to about 1500 or 1800 deg. Fahr. to start the reaction, after which the temperature rises rapidly and exortherimcally. The reaction may be represented by the following equations:

When using the usual iron oxide Fe_2O_3:

$$Fe_2O_3 + 2KAL_2Si_2O_8 + 2Al_2O(OH)_4 + CaO = 2Fe + 4Al_2O_3 . 6SiO_2 . 2KOH . CaO + 3H_2O.$$

In the presence of carbon:

$$2Fe_2O_3 + 2KAl_2Si_3O_8 + 2Al_2O(OH)_4 + 2C + CaO = 4Fe + 4Al_2O_3 . 6SiO_2 . 2KOH . CaO + CO + CO_2 + 3H_2O.$$

An examination of these equations discloses that the slag is a vitreous mixture of alkaline nature having all the elements required to make glass. The carbon dioxide and water, of course, pass off as gas. During the formation of the slag and the re-

duction of the ore the bath boils violently, which insures a thorough mixture of the reagents.

The slag is very fluid, which, together with its alkaline nature, makes it particularly effective in removing phosphorus and sulphur from the metal.

As will be seen the chemical nature of this slag makes it necessary to provide both the matte and the open-hearth furnace with a basic lining.

When making exothermic steel directly from the ore a stack furnace is used, the product of which is a matte. The matte is then charged into a basic open-hearth furnace where the metal is precipitated out of the gangue in the shape of a metal of unusual fineness.

Fig. 1 shows a general outline of the exhaust furnace used for making steel directly from the ores. It consists of a stack furnace with a water-cooled bosh and is provided with a basic

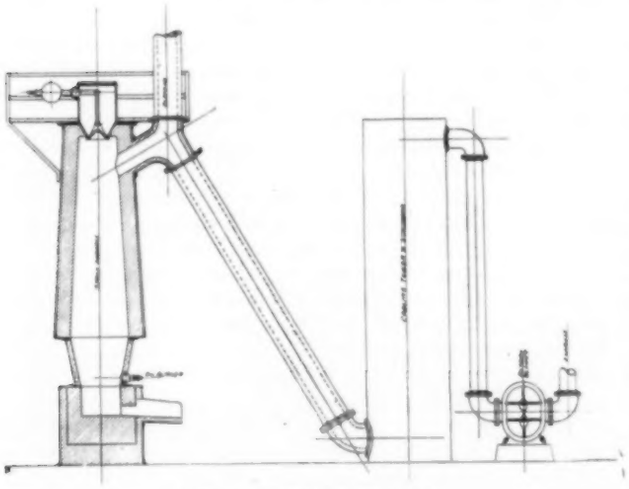


FIG. 1.—EXHAUST FURNACE.

lining at the hearth. The products of combustion are drawn off at the top and through the cooling tower or its equivalent by the exhaust blower.

The cooling tower and scrubber may be of the open type with sprays of water for cooling and scrubbing or arranged to cool by contact with cooled surfaces and deposit dust by centrifugal action.

Instead of the usual blast pipes at the tuyeres, oil or gas burners are provided. The function of these burners is to provide heat for starting the exothermic reaction and also to maintain this temperature should an excess of carbon bring it below the igniting point.

The products of this combustion ascending the stack act as a reducing agent upon the ore and make it possible to use less coke and more oil or gas fuel.

These oil or gas burners are specially designed for this furnace and are arranged to use air under pressure. The control is arranged so that an oxidizing or reducing flame can be produced at will.

A reducing flame will be required at most times, but the quantity of carbon and hydrogen introduced at the tuyeres is under constant control, as it should be.

If it were not necessary to keep the charge in the furnace in a porous condition the entire reduction excepting that done by flux might be accomplished by the fuel entering at the tuyeres.

Ten per cent of coke is charged with the ore to keep the burden open to the rising gases.

The charge is admitted as in usual blast furnaces through the bell and hopper device shown at the top, while the liquid matte is drawn off at the bottom at intervals as required. It will be noticed that hot-blast stoves are not used. The economy of using stoves and gas engines for operating on the waste gas is a matter for future consideration.

In some respects the action of this furnace and the method of operation are similar to the electric reduction furnace method where the coke charged is a little more than that theoretically required to reduce the ore, and the heat required for the reduction is supplied by an electric current. The difference is that in the exothermic process the coke and oil fuel are less than the theoretical amount required, part of the ore being reduced and the necessary heat being furnished by the exothermic reaction of the flux. Instead of using coke to the extent of about 75 per cent of the ore, but 10 per cent is required in the charge plus the equivalent of about 15 per cent of coke in the shape of oil or gas at the tuyeres, or a total of 25 per cent.

This represents therefore a saving of two-thirds of the fuel required in the present blast furnace made at an expenditure of about 13½ cents per ton of steel for flux to produce the heat corresponding to the electric current. It will be noticed that the heat is produced where required, that is, within the charge itself.

The slag is of a different nature than is usually encountered in steel processes. An examination of the equations will show that it is in the form of a glass, being a mixture of lime, potash and silica.

This slag acts as an effective protection to the metal as it passes down the shaft and into the matte in the crucible. It must be remembered that the metal does not appear in its free state in the stack furnace, but that it exists in a state of solution or similar condition, or perhaps even as a silicate of iron, although the writer is inclined to doubt this.

At any rate, the metal is thoroughly protected from the action of the oxygen and nitrogen by the reducing flux surrounding it.

A peculiar property of the process is that no precipitation of the metal takes place in the matte furnace as long as the fresh gangue is being added from the charge. However, when the matte is placed in the open-hearth furnace and brought up to the usual temperature it will swell up into a spongy mass and precipitate the metal. It is then drawn into the ladle and disposed of in the usual way. The open-hearth furnace is prepared before it is charged with sufficient carbon to give the desired temper to the metal. The results show that the metal in the bath is more uniform in carbon and other constituents than the open-hearth steel as made at present. The metal lies on the hearth as quietly as crucible steel and shows no violent

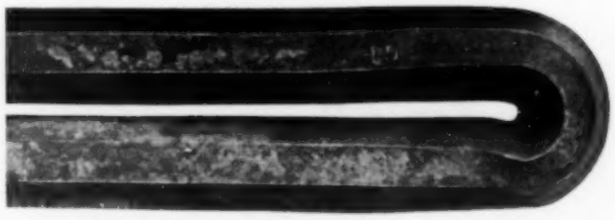


FIG. 2.—1-IN. OCTAGON BAR OF 116 CARBON STEEL BENT COLD.

boiling. This is to be expected as it has been kept away from the oxygen of the air and of the flame and is protected by the reducing slag. The unusual quietness of the metal is also apparent when the metal runs into and from the ladle. Piping and segregation of the ingot are practicaly eliminated.

This reaction may be applied to refining metals by elimination of oxides, in the open-hearth furnace or crucible furnace. In this case the flux is placed in the furnace with the charge. The reaction shortens the time of the melt about 25 per cent and gives a metal that is as quiet and free from "fire" as electric steel, in fact, it approaches the quality of exothermic steel made direct from the ore.

In the actual operation of the direct reduction process the following table shows a schedule of the charge used and the cost of the various constituents:

COST OF PRODUCING EXOTHERMIC STEEL DIRECT FROM THE ORE.

TYPICAL CHARGE.

100 pounds ore at $3.75 per ton	$0.1675
2.5 pounds limestone at $2.00 per ton	.0025
10 pounds coke at $3.00 per ton	.0134
1 pound flux at $8.00 per ton	.0036
.67 gallon of oil at $.03	.0200
Labor and overhead charges	.0620
Total cost of matte containing 60 pounds metal	.2690
Cost per ton of 2240 lb. of metal in matte	10.05
Fuel required per ton in open-hearth furnace	.27
Labor and overhead charges	2.00
Cost of exothermic steel in the ingots per ton	12.32

These costs correspond to prices in the Pittsburgh district at the present time. There are many places where ore may be obtained at much better prices, such as the sand ores of the Western coast, and where oil is more available. The labor prices are probably higher than necessary after the plant is in operation on a commercial basis.

The nature of this flux and the process make it particularly valuable in reducing ores not available commercially for the present method. Silicious ores, carbonaceous ores, sulphide ores, etc., are readily reduced to very satisfactory grades of steel. The process is especially well adapted to the recovery of copper and precious metals from low-grade or sulphide ores.

Dr. Charles E. Munroe, of Munroe, Hall & Hopkins, witnessed many of the early tests made during the evolution of this process, both in the reduction of the ore direct to steel

FIG. 3.—2-IN. X ½-IN. BAR OF 3.21 NICKEL STEEL BENT COLD.

and in the refining of metal already reduced. Some of these tests were made at the George Washington University and others at the experimental plant in Pittsburgh. Dr. Munroe's assistance and advice were of the greatest value to the inventor in the early stages of the development of the process, at which time his knowledge of chemistry and theoretical metallurgy was less than at present. This assistance, together with the technical resources of the university, were of substantial aid in perfecting the process.

CHEMICAL ANALYSES.

	No. 1	No. 2	No. 3	No. 4	No. 5
Carbon	1.12	1.16	.78	.82	.45
Phosphorus	.016	.011	.012	.012	.013
Sulphur	.033	.035	.036	.030	.036
Silicon	.13	.15	.15	.10	.15
Manganese	.31	.30	.25	.32	.07
Nickel	....	....	....	3.21	....

Test Piece	Elastic Limit	Tensile Strength	El. % 2 Inches	Red. of Area	Fracture
No. 1	51,610	85,330	29.00	50.1	Silky
No. 1-T	95,350	141,360	5.33	18.7	Fine Cryst.
No. 2	58,620	87,020	29.50	42.7	70% F. Cryst.
No. 2-T	113,500	154,400	2.66	3.6	Fine Cryst.
No. 3	60,120	87,020	26.50	42.5	70% F. Cryst.
No. 3-T	102,500	162,320	6.19	17.9	Fine Cryst.
No. 4	57,590	86,260	27.50	51.2	Silky
No. 4-T*	.....	122,750	.....	....	Fine Cryst.
No. 5	68,260	90,620	20.00	41.8	Silky ½ cup.

*Test broke in fillet before any set was noticeable.

BENDING TESTS

No. 1—2" x ½" Flat Bar bent cold 180 deg. round a 1½" pin.

No. 2—1" Octagon Bar bent cold 180 deg. Flat without sign of fracture on outside of bent portion.

No. 3—2" x ½" Flat Bar bent cold 180 deg. around a 2¾" pin.

No. 4—2" x ½" Flat Bar bent cold 180 deg. around a ¾" pin.

No. 5—1 7/16" x 5/8" Flat Bar bent cold 170 deg. around a 1¾" pin

Test pieces marked "T" were heat treated by quenching in oil and drawing the temper to a dark straw color.

The physical properties of this steel are so unusual as to be almost uncanny. This is shown by some tests recently made of high carbon steels, the results of which are given. The

FIG. 4.—2-IN. X ½-IN. BAR OF 3.21 NICKEL STEEL DRIFTED COLD FROM 9/16-IN. TO 1 3/16-IN.

steel was made by the Braeburn Steel Company at their plant at Braeburn, Pa., under the personal supervision of the writer, who also weighed out the flux and had it placed in the charge at the proper place. The test pieces were prepared by him and the tests made by the Pittsburgh Testing Laboratory under his supervision. The analyses were made by the Braeburn Steel Company at their plant laboratory.

One certainly would not expect much toughness or elongation in steels of 100 carbon or better, but the tests show some remarkable results, such as an elongation of 29 per cent and reduction of area of 50.1 per cent in steel of 112 carbon. The same steel shows an ultimate strength 65 per cent higher

FIG. 5.—SAME BAR AS FIG. 6 SHOWING FRACTURE.

FIG. 6.—45-CARBON STEEL BENT COLD WITHOUT ANNEALING.

than the elastic limit, and a cold bend of 180 deg. around a 1½-in. pin. This steel heat treated and made so hard that a center punch refused to make a mark shows an elongation of 5.33 per cent and reduction of area of 18.7 per cent.

The bending of test piece No. 2 is shown in Fig. 2. This shows a 1-in. octagon bar of 116 carbon steel bent 180 deg. flat without sign of fracture on the outside. The operator of the

testing machine remarked, "I would believe the carbon had been determined by the color method by a blind chemist if it were not for the appearance of the fracture!" Fig. 3 shows a 2-in. x 2½-in. bar of specimen No. 4 of 3.21 nickel steel bent cold to a radius of about one-half the thickness of the bar. The piece shown in Fig. 4 is cut from the end of the bar in Fig. 3 and shows a cold drift from a 9/16-in. drilled hole to 1 3/16 in. Comparison of the holes will show the extent of the drift. This test was made by driving drift pins into the hole with a heavy sledge.

Fig. 6 shows a specimen of analysis No. 5 bent cold just as it came from under the hammer. It shows a bend of 170 deg. on a diameter of about three thicknesses. The size of this bar is ⅝ in. x 1 7/16 in., and it drifted cold from 9/16 in. to 15/16 in. before tearing out at the side. Many more examples might be submitted, but they would take too much space.

It will be noticed that the general composition of the steels in Nos. 3 and 4 is about the same except for the nickel and the results show that the carbon steel is every bit as good as the nickel. In fact, test piece No. 5 shows physical properties better than are usually expected of nickel steel. This bears out Mr. Fogler's contention that ordinary carbon exothermic steel gives better results than the usual nickel steel, especially as he has demonstrated it in practice.

The ability of this steel to meet the requirements of high-duty steels at a cost of manufacture less than that of the present steels will probably solve the rail problem, and many others where high wearing qualities and resistance to shock are necessary. It is not at all unlikely that with structural steels made by this process the allowable fiber stress will be raised from 16,000 to 20,000 lb. with its attendant saving in weight and cost.

Pittsburgh, Pa.

An Automatic Continuous Recorder of the Weight of Material on Belt and Bucket Conveyors, Cable Railways, Etc.

Scientific management has become a catchword in the operation of modern large-scale industrial plants, and not in the least in chemical and metallurgical works. Just as any industrial enterprise cannot be carried on satisfactorily without an exact method of bookkeeping so in modern chemical and metallurgical works accurate daily balance sheets of all phases of the operation are needed. These balance sheets must cover two phases especially, namely, first, the quanities of the materials which enter the process and of all the products, and, second, the quantities of the energy (fuel, electric energy, etc.) involved in the process and the changes of the energy during the process.

While in power plants exact records are now used everywhere by means of recording wattmeters, etc., the same principle of exact continuous records has not yet been applied to the weighing of materials. True, on a smaller scale, especially where very expensive products are involved, it has always been customary to carefully weigh the raw products, but in operations on a larger scale careful weighings have been often considered to be too troublesome, so that instead more or less inaccurate estimates have been relied upon. The reason has been that while it was understood to be highly desirable to weigh carefully all the materials, that it was thought to be too troublesome and too expensive. The ordinary weighing hopper scale has done excellent service, but the careful and expensive attendance is required and the delays involved in the weighing have proven in some respects troublesome.

The Merrick weightometer, which will be described in this article gives an accurate continuous record of the weight of material transported by belt and bucket conveyors, cable railways, and overhead transporters. It permits continuous and accurate control of the quantities of raw materials or supplies brought into a plant, of the outgoing material loaded into boats, carts or stock-bins, and also of all the partly finished materials which are being transferred from one department to another. A secondary advantage which, however, will be appreciated by many superintendents, is that the weightometer gives exact information on the total of material handled by rubber belts, etc., during their total life, so that it is possible to get from the record a reliable estimate of the advantages of the different types of belts.

The weightometer (Fig. 1) consists of a pair of weighing levers *L*, a steelyard or beam *B*, similar in principle to those of the usual platform scale, but of special design so that a short section or portion of the conveyor can be suspended from the weighing levers.

The weight of the load on this suspended portion of the conveyor, regardless of its distribution, is at any instant automatically counterbalanced by the buoyancy of a cylindrical iron float suspended from near the long end of the weighing beam

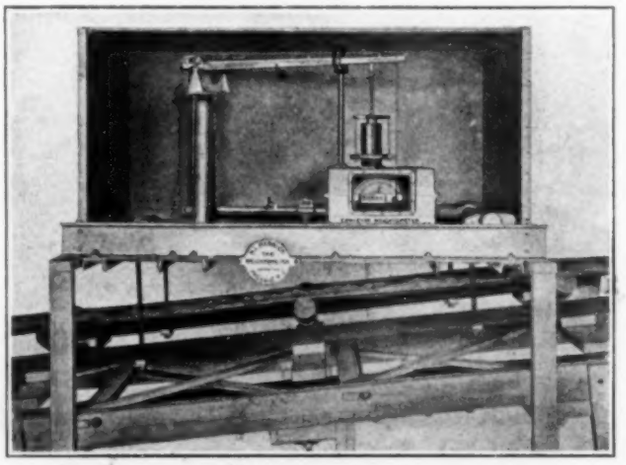


FIG. 1.—VIEW OF WEIGHTOMETER ON BELT CONVEYOR. FRONT SHEET OF CASING REMOVED.

and partially immersed in a bath of mercury. Any increase or decrease of load on the levers will either raise or lower the float in the mercury until the loss or gain in buoyancy compensates for the variation in load.

The function of this float is to insure that the movement of the beam from its zero position, or position when the conveyor is empty, be proportional to the weight of material at any instant on the suspended portion of the conveyor.

The extreme end of the beam is connected with a totalizing mechanical integrator, which derives its other factor from the travel of the conveyor by means of suitable gearing from a bend pulley on the return belt or a sprocket wheel if on a bucket conveyor.

This integrator thus continuously totalizes the product of two quantities, one proportional to the weight of material suspended and the other to the travel of this material. The result, therefore, represents the total weight of material and is plainly indicated by a register in units and tenths of units of either a short ton, long ton or metric ton.

For cases where the material handled adheres to the conveyor in a varying amount, an attachment is added that automatically counterbalances the variable weight of the empty conveyor. This avoids frequent adjustment to meet the changes in the weight of the empty conveyor and material that may adhere thereon.

It is, of course, easy to transmit by electro-magnetic means the reading of the scale register to the office of the superintendent, or to any other point distant from the scale itself, so that the superintendent or manager knows always what is going on.

The integrator (Fig. 2) consists of an aluminium disc *X* around the periphery of which are mounted rollers *Y* free to revolve. These have their axes tangential to the edge of the disc, and form practically a continuous annular roller which cannot move around the disc.

The disc is fixed on a shaft that revolves in bearings on the frame *Z*. This frame is mounted with a bearing at either end so that it can rotate about an axis coincident with the plane of the disc and at right angles to the axis of the disc. On one

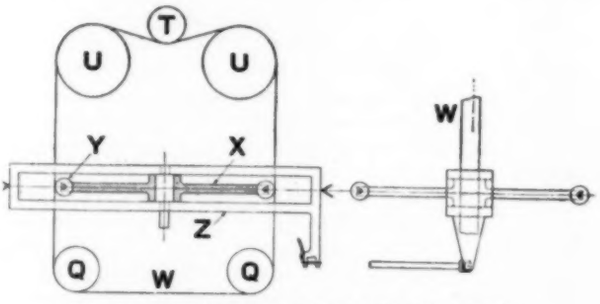


FIG. 2.—DIAGRAMMATIC SKETCH OF INTEGRATOR.

end of this frame is an arm the extremity of which is connected by a link to the long end of the beam. Thus any movement of the beam caused by an increase of the load on the belt tilts the frame through an angle whose sine is proportional to the vertical movement of the float, and again proportional to the load on the suspended portion of the conveyor.

Four pulleys *UU*, *QQ*, guide a small endless belt *W* around the disc and touching the rollers thereon at two points diametrically opposite and on the axis of the frame.

Pressure rollers behind the belt (not shown in the diagram) keep the belt and disc rollers in contact. A weighted take-up pulley *T* assures an even tension in the belt and takes care of any stretch. The two pulleys *UU* are geared together and are driven by means of mitre gears from a bend pulley under the return belt. The integrator belt thus travels at a speed proportional to that of the conveyor.

So long as the plane of rotation of the roller *Y* is parallel to the direction of the integrator belt the motion of the latter will only affect it to the extent of revolving the roller on its own axis. This condition corresponds with the zero position of the beam or when there is no load on the conveyor. If, however, the beam is deflected by the loading of the belt, the frame *Z* and disc *X* will be correspondingly tilted. This will incline the axes of the roller *Y* with respect to the integrator belt. Then, besides rotating them, the belt will push the rollers sideways across its face at a rate proportional to their inclination. As the rollers cannot slide on the disc they will rotate it around its axis. Consequently the speed of rotation of the disc is proportional to the deflection of the beam, the weight is carried on a screw and is similar to that on the ordinary platform scale, as turning the screw moves the balance weight.

It is interesting to note that the Merrick weightometer has passed the experimental stage for a few years and has proven exceedingly simple in operation. The chief practical advantages are that the operation is entirely automatic, so that there is no expense for any attendance. It is very easily installed, and the only supports required for the weightometer are quite simple and inexpensive, due to the simplicity of its design and construction. It has been possible to make it durable and robust.

The recording being continuous, the accuracy is not affected by vibrations of the beam whether due to irregular loads or lack of rigidness of the structure. These vibrations are necessarily an equal distance either side of the true position and the average result unchanged by them.

As structures on which the conveyor and weightometer are erected are seldom ever free from vibration, this feature constitutes a prominent point of advantage.

The Merrick weightometer is built by Herbert L. Merrick, of Passaic, N. J.

The Western Metallurgical Field.

Search for Tin.

Tin has been attracting considerable attention in the West and strong efforts are being made to develop a production more in keeping with consumption in the United States. In South Dakota, Texas, Washington and Alaska tin has been found and some mining has been carried on. In Texas especially competent engineers who have examined the lode, near El Paso, consider the possibility of developing a satisfactory ore body to be excellent. The owners, however, have never been willing to spend the necessary amount of money in underground development and the effort to make the mine produce before it was ready has resulted in discouragement.

On Seward Peninsula, in Alaska, both lode and stream tin are found. Dredging last year resulted in the shipment of 90 tons of concentrate from Buck Creek, worth $590 per ton. The concentrate was sent to England for treatment, but future shipments are to go to Tacoma, Wash. Lode mining has been less successful despite the fact that the deposit is said to be 10 ft. wide and to have been traced 3000 ft. It is said to average 2 per cent tin and 1 per cent tungsten. The character in depth has not been determined.

Near Hot Springs stream tin has been known for at least three years and under the guidance of Falcon Joslin, of Fairbanks, a Mr. Robinson has been making a careful search for the lode. It was announced some time since that it had been found and details are now at hand. The ore body is associated with an "altered rhyolite" occuring as a dike which has been traced 10,000 ft. across the heads of Sullivan, Tofy and Idaho gulches. The actual ore body has been shown by trenching and cross-cuts to be 12 ft. wide and to extend 3700 ft. along the strike. The average value has not been determined, but cassiterite occur in the rock in microscopic particles and ore is certainly of value.

Encouraging Outlook in Alaska.

Alaska is well on the way of a busy season. It is announced that twelve new dredges are to be erected at Nome; the Guggenheims have bought the most important claims at Iditarod and are slipping one of the Dawson dredges down; hydraulicking on the Kenai peninsula started early; Ruby Creek is sending out good reports and some gold; the Perseverance and the Sheep Creek properties at Juneau have come under control of B. L. Thane and associates and will doubtless be placed in good shape, and the new concentrator at the Bonanza mine, Kennicott Mines Company, has begun work. It is interesting to note that this concentrator, which handles the second grade of the much-discussed Bonanza mine, works on material containing 25 per cent copper. The product assays 65 per cent copper and 18 oz. silver. W. H. Seagraves, formerly of Ely and later at La Touche, is now in charge at Kennicott. He has started work on the Jumbo, a claim near the Bonanza. It is expected that copper shipments from the Bonanza this year will total 40,000,000 lb. as against 23,000,000 lb. last year.

Revival of California Miners' Association.

California mining men propose to revive the California Miners' Association which did such valiant work in the old days of contest between the farmers and the hydraulic miners. Of recent years the Association has had only a nominal existence. It is proposed to revive it and to call a meeting next November to which other Western states will be asked to send delegates, with a view to arranging for proper exhibits and representation at the Panama-Pacific Exposition.

That the latter must include a first-class exhibit relating to mines and mining, is felt to be a matter of first importance to the Western mining industry in particular, and such an exhibit can only be assured by arranging promptly for wide and hearty co-operation. Since, however, the Association is to be revived, it is likely that so viril an organization as it long was, will find many fields of usefulness. The committee in charge consists of Charles G. Yale, E. B. Braden, and W. C. Ralston.

Another matter which is attracting attention in San Francisco is the International Engineering Congress which is to be held in 1915. A strong local committee has been formed and the bulk of the required guarantee fund is already in hand.

Treatment of California Zinc-Copper Ores.

Zinc ores are the subjects of much investigation in California just now, though not yet a source of profit. Considerable quantities of zinc ore have been developed in Shasta County, all of the copper mines containing a good deal of zinc, while several have proved in depth to contain more zinc than copper. The ores cannot be treated in ordinary Belgian furnaces, since the blende is associated with so much chalcopyrite and pyrite, and there is no source of fuel supply in the district.

Much study has been devoted to methods other than ordinary smelting. Two of the companies, the Afterthought and the Bully-Hill, announce that they have met with enough sources to justify development. The Afterthought Copper Company operated its copper smelter at Ingot, 20 miles east of Redding, for a time on ore averaging 3.4 per cent copper, 15.3 per cent zinc, 6.4 oz. silver and 60c. gold per ton, but later shut down. For some time S. E. Boetherton, who is general manager and metallurgist for the company, has been at work upon a method for treating the ore, and it is now announced that a 25 or 50-ton plant will soon be constructed. The details of the process are kept secret since it is not yet fully protected by patent. The Afterthought company has purchased a lumber railroad from a local company and is extending it to the smelter at Ingot. The Bully Hill Copper Mining & Smelting Company, which formerly operated a copper smelter at Winthrop, has also been studying the problem, and J. B. Keating, the manager and metallurgist, is said to have had a large measure of success in devising means of treating the ore. Here again the method is kept secret.

The mammoth plant of the United States Smelting, Refining & Mining Company, may be said to be making use of the zinc content of its ores, since the 4 per cent of zinc in the smelting charge of the copper furnaces serves to neutralize the SO_2 produced in smelting and permits the filtering of the smelter furnace in a baghouse. It was hoped at the time of starting the copper smelter that a method of recovering the zinc from the baghouse fume, which contains 40 per cent $ZnSO_4$ and 20 per cent ZnO, could be devised, but no profitable method has yet been evolved.

C. J. Reed, of San Francisco, has also been at work upon a wet method for the extraction of zinc from its ores and has taken out a number of patents. A 1-ton experimental plant has been erected on San Francisco bay, but no statement has been given out as to the results attained. Engineers who have investigated the proposed process are of the opinion that it is extremely good from a chemical standpoint, but likely to introduce mechanical difficulties from the standpoint of construction and operating costs. It is too early to form an opinion. The developments so far are said to have been satisfactory.

The situation is somewhat complicated, to the producer of zinc, by the fact that there exists no great market for spelter on the Pacific coast. Zinc is chiefly used in making brass and galvanized iron; the brass industry is concentrated on the eastern seaboard, while the making of galvanized iron naturally centers around the steel plants of Pennsylvania, Ohio and Illinois. The zinc producer in California has no advantage of local markets, therefore, but has to meet the disadvantage of a longer shipping distance.

Advanced Cyanide Practice.

Within a period of five years, practice in cyaniding gold and silver ores has undergone such radical changes from the mechanical point of view, that machinery and methods which were regarded as standard a few years ago are now regarded as obsolete. Perhaps no other branch of metallurgy has changed so completely in such a short time, or has been so uniformly successful in the field to which it is adapted. In catalog No. 10C, just issued by the Colorado Iron Works Company, of Denver, Colo., may be found a brief sketch of modern cyanide practice and equipment. This booklet will be interesting and valuable to both the layman and professional metallurgist, for it embodies a concise statement of the principles of cyanidation, as discovered by MacArthur and Forrest, and gives examples of approved mechanical application of those principles according to modern ideas.

Among the principal features of present-day cyanide practice may be mentioned sand and slime classification, slime agitation and filtration, and continuous counter-current decantation. The mechanical means of accomplishing these steps, and the arrangement of mills embodying them, are all illustrated and described in the catalog. The Akins classifier, Akins-Rothwell agitator, Rothwell slime thickener, and Portland slime filter are all machines which have been developed by the company's metallurgists, and have found extended application in modern cyanide mills.

The subject of cyaniding by continuous decantation has been discussed in this journal, several methods having been proposed by Mr. John E. Rothwell.[1] In addition to these, the catalog mentioned contains another method devised by H. B. Lowden and J. E. Rothwell, in which the principle of counter-currents is applied in a simple manner. The scheme is illustrated in Fig. 1.

In this, the thickening tanks are dispensed with and a quiet space provided within each agitation tank. This annual space is furnished with inclined baffles, similar to those employed in the Rothwell thickener, which greatly increase the settling area, and the solution drawn off is substantially clear and practically no solids are carried back by it. To remove any turbidity of the solution previous to precipitation it is passed through a clarifying filter previous to going to the gold tank. The method of operation is as follows:

A, *B*, *C*, are Akins-Rothwell agitation tanks arranged for continuous series agitation and each fitted with an inner cylinder A_1, B_1, C_1, and an overflow launder L_1, L_2, L_3. In the annular area between the cylinder and the curb of the tank are placed inclined baffle plates, the tops of which are submerged.

The slime pulp to be treated flows from the grinding mill to the space within the inner cylinder A_1, in which it is kept agitated by pneumatic or mechanical means, or both. A definite proportional part of the pulp is cut out continuously by the cutting vane and passed on to the space in the inner cylinder B_1, in which the same operation takes place, the pulp passing to tank *C* and so on to the subsequent tanks of the series.

While this operation is going on, barren cyanide solution is passed from tank, *W*, through the meter, *M*, into the space in the inner cylinder of tank *C*, or the last tank of the series when more than three tanks are used, and this solution mixes thoroughly with the pulp being agitated, thus diluting the values carried in solution. Separation of the solids from the liquid is made by gravity in the quiet annular space 3, the solids remaining in the tank while the solution overflows the weir into the launderer L_3 in quantity equal to the inflow from *W*. From the launder L_3 the solution flows to the space in the inner cylinder B_1 of tank *B*, in which the action and operation are the same as in *C*, the overflow going from the space 2 to the inner cylinder A_1 of tank *A*.

[1] This journal, Vol. IX (1911), pp. 373 and 439.

The counter current solution, passed from *W* into *C*, diluting the values in solution in that tank, flows back through the series of tanks, coming progressively in contact with richer pulp and gathering values in its course, finally overflowing from *L*, carrying a maximum value. This is the solution which is precipitated, for which purpose it is passed through the clarifying filter, *F*, to remove any turbidity and thence to the gold tank, *G*, from which it flows to the zinc-boxes, *Z*, in which the gold and silver are precipitated. The barren solution from the zinc boxes flows to the tank, *S*, from which it is pumped back to the tank, *W*, is built up in cyanide strength and re-enters the circuit.

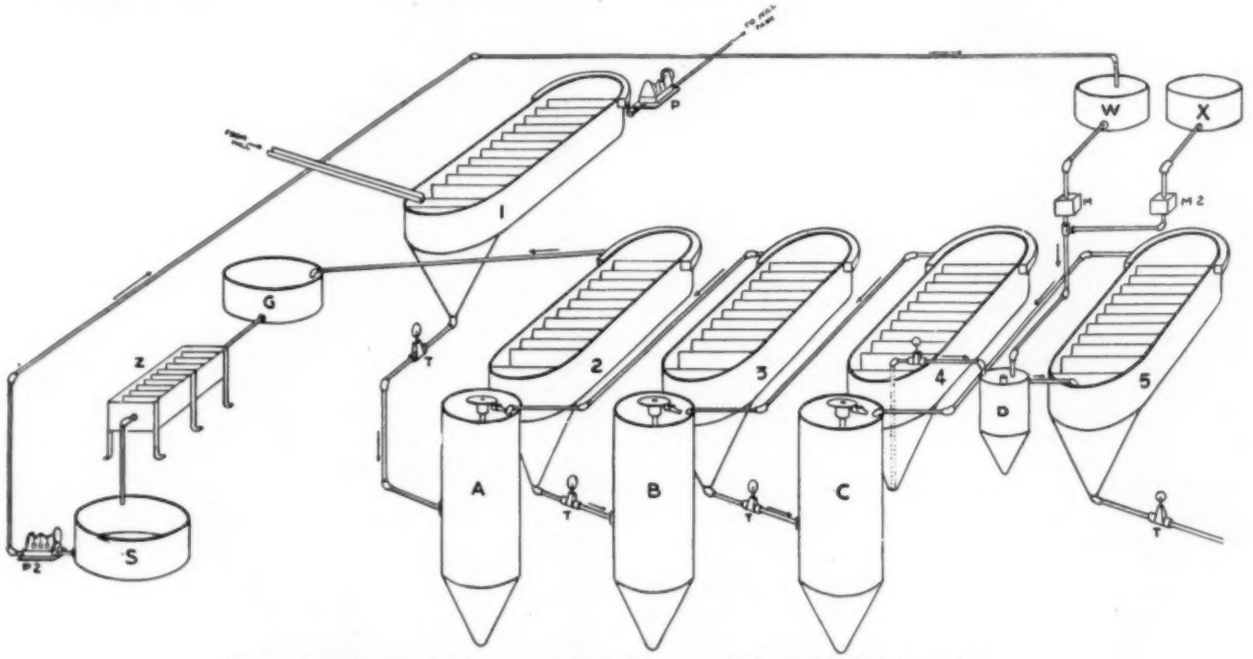


FIG. 1.—ROTHWELL-LOWDEN COUNTER-CURRENT METHOD OF CONTINUOUS AGITATION.

In the meantime the pulp has been passing through the series of tanks in a direction opposite to the flow of the solution, whereby it progressively comes in contact with solution lower in dissolved values and higher in free cyanide as the pulp becomes reduced in value, finally passing from *C* into the collecting tank, *D*, from which it goes to the slime filter. This filter separates the pulp and washes from it the soluble values it carries, delivering the solids to waste. The filtrate, being low in value, passes back to the grinding mill circuit, where it is built up in cyanide strength and resumes its flow through the system.

In addition to the foregoing, the catalog contains useful tables on capacities of tanks, equivalent rates of flow of water, slime density relations, and other information of value to the engineer.

A Recent Evaporator Test

In the following article we give the results of an interesting recent evaporator test, made by Mr. Charles L. Weil, consulting engineer of the Diamond Crystal Salt Company, of St. Clair, Mich. The evaporator under test was a quadruple-effect evaporating system at Ludington, Mich., constructed by the Rapid Evaporator Company, of Detroit, Mich., under the Faller patents. This 24-hour test was made on June 28 and 29, with a shut-down of two hours on the night of June 28.

The essential features of the test in question were the determination of the pounds of salt made per pound of steam used and the conditions maintained with respect to incrustation of heating surfaces during the making of the salt. The test also furnished data as to the rate of salt making for these specific pans or effects, for the amount of salt in barrels or tons that could be made with a ton of specific coal and as to the ratio of steam supplied to water evaporated.

In order to determine the steam used the drip from the "steam belt" of the first effect "pan" was conducted, alternately, to two calibrated measuring tanks, passing on its way through a cooling coil, and thus a record was secured of the weight of steam used. The temperature of the water running into the tank was taken each time a tank was filled. The calibration gave a value for the weight of water in a tank, when filled to a specific mark, of 1550 lb. of water at 128 deg. Fahr.

The records gave a total of 33 29/44 loads or tanks, each of 1550 lb., or a total of 52,172 lb. of condensation for the 24-hr. run. A check of the measurement showed that it had been quite accurate.

The determination of the amounts of salt made in the different effects showed that 11,241 lb., 6940 lb., 12,003 lb., and 18,454 lb. were made in the first, second, third, and fourth effects respectively, for the entire period of 24 hours.

The total "moist" salt made was, therefore, 48,638 lb. The moisture in five samples was 7.21, 6.11, 6.39, 4.72, 4.44 per cent, average 5.77 per cent. If "commercially dry" salt is assumed to carry 5 per cent moisture, the 48,638 lb. of "moist" salt produced correspond to 48,263 lb. of "dry" salt. Since the total steam used was 52,172 lb., the number of pounds of salt made per pound of steam is 0.925 lb.

With steam supplied at atmospheric pressure, the figure is 0.921 lb. of dry salt per pound of steam at atmospheric pressure. It should be noted, however, that during the test the drip from the first effect steam belt was caught and measured, and not passed on to the second, third and fourth effects as is the custom in this system in regular practice. If an allowance is made for this in a conservative way, the amount of salt made per pound of steam would have been increased 9 per cent by passing the drip through the several effects, giving 1.004 lb. of salt per pound of steam.

On the foregoing basis, the results of the tests are, therefore, as follows:

20,080 lb. or 71.7 bbls. (of 280 lb. each) of salt are made by 20,000 lb. of steam or 71.7 bbls. (of 280 lb. each) are made by 1 ton of coal, where coal will evaporate 10 lb. of water from and at 212 deg. Fahr.

In Mr. Weil's report on the test, attention is called to the

fact that the system, at the time of the test, had been operated the greater part of one year without "scaling" the tubes. Investigation showed a slight scale on the tubes of the higher temperature "effects," that is, the first and second pans. This slight scale undoubtedly decreased the efficiency of the system. Taking this into account and also the conservative estimate made of the effect of the drip in the second, third, and fourth pans, Mr. Weil concludes he may safely place the ratio under consideration, in comparison with similar tests, having especially prepared apparatus, as, using a coal as above, *seventy-five barrels of salt per ton of coal.*

The brine used during the test was saturated and fed to the pans at a temperature of 160 deg. Fahr.

The ratio of evaporation, steam to steam, was approximately 1 to 2¾.

The total amount of salt made during the 24 hours run was 172 bbl.

The matter of incrustation of heating surfaces in the case of these pans is one of great interest. No arrangement is provided for boring or scaling the tubes and although the pans are reported to have been run the greater part of one year and never scaled, still the tubes show but a very light scale. A sample of this scale was analyzed and found to consist chiefly of calcium carbonate.

An explanation, in part, of the scale is to be found in the daily use in these pans of tri sodium phosphate, though it is claimed to be used but in limited quantities, say 25 to 30 lb. during one day.

With regard to the auxiliaries, it is noted that provided the power required for driving same, calls for a steam consumption within the requirements of steam from the first effect apparatus, then the only heat loss experienced would be that due to condensation and radiation in connection with the engines driving these auxiliaries and this would be a loss incidental to all such systems, but relatively low in amount in the case of a "quadruple" system. In this case the auxiliaries were electrically driven and a special determination of the power, showed, not allowing for efficiency of motors, that the average horsepower required to drive the auxiliaries, is 58 hp. The available steam for this amount of power, for use in the pan should be, using a fairly efficient engine, within the requirements of the system.

Consequently, no unusual loss of heat is anticipated in connection with driving the auxiliaries.

The following table gives analyses of the "raw" and heated brine used and also an analysis of one sample of the salt made:

	Raw Brine.	Settled Brine.
Specific gravity at 15 deg. C.....	1.2019	1.2093
Total Solids	25.65%	26.740%
Calcium Sulphate ($CaSO_4$, $2H_2O$).....	0.58%	0.559%
Calcium Chloride ($CaCl_2$, $6H_2O$)	0.16%	0.188%
Magnesium Chloride ($MgCl_2$, $6H_2O$)....	0.05%	0.051%
Sodium Chloride (NaCl).....	24.86%	25.942%

Sample No. 1 of salt shows 0.77%, calcium sulphate $CaSO_4$. $2H_2O$.

As to the evaporator design it is interesting to note that each pan contains 402 copper tubes, 3 in. inside and 3⅛ in. outside diameter.

The 402 copper tubes have an effective length of 38½ in. Consequently the heating surface is, very nearly, 1055 square feet. This is, relatively, a larger amount of heating surface than Mr. Weil has met with, for corresponding outputs in his experience.

The salt produced was a high-grade "granulated salt" with respect to color and coarse "grain."

Mr. Weil concludes, that while we have no acknowledged standard method of testing such apparatus as that we have under consideration, yet the results of evaporation (75 bbl. of salt per ton of "10-lb." coal) are excellent and that the salt produced is of a superior nature.

Synthetic Rubbers.

It will be interesting to read the following British press views on the synthetic rubber situation.

In the *Engineering Supplement* of the London *Times* of July 19, Prof. Henry E. Armstrong writes as follows under the heading "The Production of Rubber—With or Against Nature":—

"The question whether ultimately rubber will be produced with advantage by artificial means is one which has many sides that may well be discussed at the present time. In every case the foundations of success are laid beforehand, and as we have sown so probably shall we reap; if it appear that we have not always sown well, by taking stock of the situation we may find ways in which we can do better in future.

"The problem is one of great public and practical importance. The capital at stake is very large already and will become far larger. As its qualities are recognized and it is cheapened in cost, the uses of rubber will be multiplied and the demand will enormously increased. But, be it remarked at the outset, it is useless to think of present prices ruling in the future; at no distant date, rubber will be regarded as so indispensable that, in some way or other, the cost must needs be lowered.

"Chemical Processes and Their Chances.—The statements made recently at the Society of Chemical Industry, regarded from the practical side, though suggestive, are incomplete. Nothing that is new in principle was brought forward. Processes were outlined of an interesting character from a scientific point of view, but definite information on which judgment of their practical value could be based was wanting. In such a case, as in many others, before it can be eaten the hare must be caught. The primary difficulty in manufacturing rubber artificially is to find suitable raw material. It is said the difficulty is overcome, and we are told that it is to be starch, which is first to be converted into butylic alcohol by a fermentation process. Chemists have long been familiar with methods of making the alcohol by bacterial action, but these have never been applied except on a laboratory scale. Step number one, therefore, will be the foundation of a new fermentation industry. Though difficulties as often disappear as they appear on translating laboratory practice into work practice, fermentation processes of promise have ended in practical failure before to-day, as in the case of citric acid, for example. The question of patents will also have to be considered. There is no novelty in making "higher alcohols" by means of organisms; the most that can be done probably is to protect the use of a particular organism in a particular way for a particular purpose, and it is by no means certain that the field is not fairly open to all whom it may concern.

"Much importance is attached also to the discovery that sodium is a particular effective agent for use in converting the very volatile hydrocarbon isoprene and similar substances into rubber or a rubberlike material. It is more than probable that the conversion may be effective equally well by other means. Apparently the polymerization process is one in which the active agent is either an alkali or an acid; the principle involved in the use of such materials cannot now be protected by patent, and it will, therefore, be open to chemists to discover various ways in which they can be applied with advantage.

"The material ultimately produced from butylic alcohol is not ordinary rubber but a rubber-like material, and doubtless not the only one to be found. In other words, the field may be a large one, and it may be possible to make such materials in a considerable number of ways. Though all to the good, so far as the public are concerned, this circumstance may effect materially the value of any individual set of processes that it is proposed to apply in practice. In fine, it is probable that success will depend more effective organization that on the possession of any particular set of patents.

"German Resources.—It is well, therefore, that there should

not be excessive jubilation by English chemists at a victory or two gained in the laboratory over German chemists. There is reason to believe that the German works have knowledge at their disposal which render them independent of Professor Perkin and his associates. Moreover, the technical resources at the command of the Germans are far greater than any we possesses [in Great Britain]. Here comes the point at which we have failed to sow properly. The Germans are fortunate in possessing a large number of works which are simply University laboratories turned into huge manufacturing establishments, such as the Badische, Anilin und Soda Fabrik, Bayer and Co., and Meister, Lucius and Co. There is not one such establishment now in English hands.

"When 20 or more years ago it was a question of developing the manufacture of artificial indigo, it was a small matter for a firm of such consequence as the first above mentioned to spend nigh on a million pounds sterling in bringing the process to perfection, and in the end they merely add a new section to their works. So it will be with artificial rubber; if desirable processes will be perfected, at whatever cost, and another new department will be created in the works. The German manufacturers have an extraordinary fund of experience and an army of drilled and disciplined workers at their command; everything, in fact, is organized up to the hilt, and the development of the artificial rubber industry will be a matter of small concern to people equipped as they are.

"Here [in Great Britain] the industry must be started, not as a branch industry, but *ab ovo* and independently; its complete organization must be effected practically without external assistance. The expenditure before success is assured will necessarily be very large, and probably many fingers will be burnt in the preliminary work. When success comes what will be the position? The three months' start which has been the cause of jubilation will have been sacrificed, and one or other or several of the German firms will be far ahead and possibly will have acquired a commanding grip of the market.

"Why is it that we [in Great Britain] are so much behind? Our present inability to manufacture coal-tar colors is the consequence of breakdown not on the scientific side but on the business side. We fail because we remain Philistines—because our schools and universities are governed by literary ideals alone. If we desire to recover our position we could not do so now without the sacrifice of millions probably—simply because the Germans have acquired control of the markets of the world and could and would undersell us everywhere. As we have sown so must we reap. If we are to repair our past errors we must be prepared to take heavy risks and lose much in the process; in one way or another, we must pay for our mistakes. The rubber industry perhaps offers an opportunity and it is one that should be taken at all risks—but with eyes open to the risks.

"*Artificial Versus Natural Rubber.*—Will artificial rubber succeed in competition with natural rubber? Perhaps not if there be actual competition. But the question is—may there not be room for both? The answer is in the affirmative; both natural and artificial rubber should be remunerated industries if from the outset producers of the two articles work together and do not allow an unholy spirit of competition to arise. Here again a lesson can be learned from Germany. In early days the firms there were all in competition and there was endless litigation over patents; in consequences the prices of dye-stuffs were reduced to figures which were absurd, taking into account the skill and knowledge involved in their manufacture, and were unnecessarily low even from the dyer's point of view, in view of the fact that a little dye-stuff goes a long way and that its cost bears a small proportion to the total cost of manufacture of the dyed goods. Of late years, recognizing the absurdity of the position, the German manufacturers have combined and agreed to work together. Litigation is rarely heard of. At the same time we have been misled into altering our patent laws in a manner entirely favorable to foreign interests, by nominally requiring that goods sold here should be manufactured here. Technical compliance with the Act involves so little that it is practically inoperative, but it has been the last straw in upsetting struggling industries here, and, what is worse, has been greatly to the advantage of our competitors in foreign markets.

"But is it desirable to make rubber artificially? The question may seem to be of little more than academic interest considering the progress already made. The Germans will make rubber if we do not; indeed they are doing so already. Yet it is worth while perhaps to think the question over and consider whether, in the long run, it pays to make rubber from starch.

"We are competing with Nature in many directions at present and it is very desirable to discuss whether in the future it will be either desirable or possible to work so much against her. Practically all the natural coloring matters are now supplanted by artificially-made dye-stuffs, which, in the case of the more important, such as indigo and madder, are identical with the natural products. The alkaloid quinine, which is extracted from cinchona bark, though not displaced and in no way equalled yet, has many rivals made in Germany, which are often used when formerly it alone was prescribed. These coloring matters and drugs are in most cases made from that universal provider, coal-tar, and the manufacture of dye-stuffs from coal-tar and the consequent displacement of natural colors may be justified on at least two grounds: (1) Constituents of coal-tar which are otherwise of little value, if not valueless, are made use of as raw materials; and (2) the land on which madder and indigo were grown is now set free and can be used in raising food crops.

"*Starch Too Valuable.*—But rubber, we are told, is to be made from starch. In making it from this material we shall not only be withdrawing land now used in raising food crops, but in a sense we shall be using up food crops (potatoes and cereals) as the raw material. The question is how long this will be desirable and possible. As we increase in numbers the difficulty of securing adequate food supplies is bound to increase. Moreover, there is a direction in which there will be a use for starch in the future which also may militate against its use as the raw material of artificial rubber. Taking into account the rapid development of the internal combustion motor and the fact that petrol will not be available for ever at present rates of consumption, it is more than probable that alcohol will come into use in its place at no distant date. The only way in which it will be possible to meet requirements will be to ferment starch and sugar produced for the purpose in hot countries, where large crops can be grown. All the indications point to a shortage of sugar and starch in the future and to an increase in their value.

"But after all, in using starch to make rubber we shall only be copying the plant, as this also makes the rubber more or less directly from starch. It is not a case of utilizing a waste product—such as coal-tar was when dye-stuffs were first made from it, and such as it would be still in the absence of the color industry—but a material is to be used which is of particular value for other purposes already. Ethically we shall probably be making a mistake in not availing ourselves to the full of the activity of the plant; but, apart from this, it may be well that, when everything is taken into account, the plant is able far more effectively than man to make rubber from starch. It is of the utmost importance, from this point of view, that the production of natural rubber should be made a scientific industry. In the case of indigo the margin in favor of the artificially made material is not so very great; had the planters taken time by the forelock it is not improbable that they would have held their own. It will be well if rubber planters take the lesson of indigo to heart and learn without delay to set and keep their house in perfect order."

* * * *

The London *Truth* of July 3rd writes as follows under the heading "Synthetic Fiddlesticks":—

"In reading through the mass of synthetic advertising twaddle with which, much to the alarm of rubber investors, Mr. E. Halford Strange has flooded the press of this country [England], I felt that sooner or later the boundless imagination of this enthusiast would lead him to extend his claim far beyond such prosaic substances as fusel oil and synthetic rubber. And, indeed, Mr. Strange has rapidly developed into a synthetic whole-hogger. After explaining to the representative of a weekly contemporary that the aim of his group of multi-millionaires was not wholly financial, Mr. Strange is reported to have said: 'Yes, we have commenced the attack on other attractive problems—the synthetic manufacturer of glycerine, of fats, of copals for varnish-making, of gutta-percha. Later we may venture to attempt the production synthetically of the nitrogenous constituents of food itself—proteid. This proteid is the expensive nitrogenous constituent of food. Synthetic proteid, if successfully produced, would probably become as great an industry as synthetic rubber, but it will be of vastly greater importance to the human race. It would mean the sudden cheapening of food itself, and another line of defense for these islands in case of war.'

"It will be seen that this Mr. Strange means not only to render possible the manufacture of cheap explosives from acetone, and to supply us, at much reduced prices, with faithful imitations of numerous industrial commodities of undoubted utility, but his future ambition apparently is to feed the whole human race with his synthetic products. With the value of his scheme in case of war the military authorities will perhaps deal, but unless forcible feeding is to be generally resorted to, I imagine that in times of peace the demand for roast-beef—even though its succulent and tender qualities may be most faithfully reproduced—will not seriously be effected by synthetic production.

"Why this alarming and apparently universal synthetic campaign, with its army of distinguished professors marshalled by Mr. Strange, should have opened with an attack on so harmless a substance as rubber has not been without mystery. But the history of the movement is thus unfolded in the prospectus of the Synthetic Products Co., Ltd.:—'In the autumn of 1909 Mr. E. Halford Strange, M. Sc., a director of Strange and Graham, Ltd., of 50 City Road, E. C., in common with the rest of the world, had his attention drawn to the high price of rubber, and it occurred to him that an organized attempt might be made towards the synthetic manufacture of rubber.'

"I half suspect that it was for the rise Linggis which attracted Mr. Strange's attention, and had news reached him that oats were rising in value the rubber market might have been spared this onslaught.

"In view of the great names associated with these wonderful discoveries, and with the prominence given to them in the press throughout the country, it was with no small amount of curiosity that I attended last week's laboratory demonstration, and I must admit that if I left the City Road cellars—the home of the rubber bogey—with precious little respect for the substance Mr. Strange was pleased to call rubber, I was not without admiration of that gentleman's marvellous imagination. Although column after column has appeared in the press about this new product, I was assured that the total output of the factory to date did not exceed 2 lb., and, stranger still, that the product had not been put to a single physical or mechanical test, the experiments so far having been wholly chemical. It appeared to me inconceivable that the product about which so much has been written should not have been compared with natural rubber, say in a simple stretching test, but I was emphatically told that on this point—the chief point so far as commercial value is concerned—no information was available.

"Fortunately, I was afterwards allowed to handle a small piece of vulcanized 'pure synthetic,' and in face of the unconvincing answers to my questions I was not surprised on simply bending the material between my thumb and forefinger to see it break, readily and cleanly, into two distinct pieces. This miserable substance, which has been trumpeted as 'tenacious,' 'nervy,' etc., is no more equal to fine hard Para or plantation rubber than brown paper is the equal of shoe leather. To discuss the cost of production of such rubbish, and to argue as to the length of time it will take before it competes with natural rubber, is to throw dust in the eyes of the public who are asked to subscribe for shares in the new company.

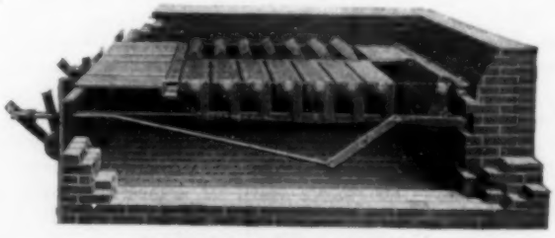
"Before going to the public for so large a sum as £450,000 it might have been expected that a respectable quantity of the material would have been manufactured and thoroughly tested by trade experts, and that it would have been submitted to the Mincing Lane dealers for valuation. The result of any such test would, in my opinion, have proved without doubt that the material is valueless, and that commercially we are no nearer the synthetic production of rubber than we were thirty years ago. The prospectus now before the public differs in some material respects from the draft to which I referred last week. The clause relating to the underwriting of the issue has now been omitted, and apparently the attempt to secure support in this direction proved hopeless. In the place of this, in return for £1800 paid to the vendor syndicates Mr. P. B. Reckitt secures 3000 fully paid "A" shares in the new company, or say, at the rate of 12s. per share, and Mr. Humphery gets at the same heavy discount 1500 of the shares, for which the public are asked to pay 20s. Another alternation is made of far greater significance. In the draft it was stated in big black type, 'It is now established that the product is real rubber.' After this and similar phrases have been used in the most reckless fashion for advertising purposes, they are quickly withdrawn, and the public are supplied with the prospectus of a company which does not claim to produce real rubber, but a substance which 'recalls' rubber.

"The manner in which the names of distinguished scientists have been used in connection with this promotion labels Mr. Strange as a dangerous enthusiast, and investors will be foolish in the extreme if they entrust the new company with a single penny of their money."

A New Rocking and Dumping Grate

The adjoining illustration shows an improved feature in a rocking and dumping grate. It consists of a large rear dump grate, which is operated independently from the main grate surface.

By means of this double-capacity dump grate the largest clinker formations can be quickly and easily disposed of at the rear of the furnace, where combustion terminates. The residue of combustion must be disposed of after the fuel has performed its heat-producing function, and two ways only are available, namely, to dump into the ash pit or clean out through the fire doors.



ROCKING AND DUMPING GRATE

In modern furnace practice the dumping process is considered the only right method. There is a considerable loss in furnace efficiency by the forward cleaning of the fires, because it disturbs combustion, and with the opening of the fire doors the heat-producing function of the furnace is destroyed and the loss represents both fuel and labor in getting the combustive areas of the furnace back to a normal active state again.

From the illustration it can be seen how convenient it is to clean these grates, especially the rear portion which ordinarily receives the least attention, because it is out of reach of the fireman. But with this wide dump grate it is really the easiest portion of the grate surface to clean.

A combination of this rocking and dumping feature entitles this grate to recognition as a modern device for coal-burning furnaces; and while it is a hand-firing device it embodies three prominent features of a mechanically fed furnace. First, the agitation and breaking up of the fuel bed by the rocking movement; second, the tendency of the rocking motion to shift the fuel to the rear, and, third, the large dumping grate at the rear of the furnace which enables the operator to dump the accumulation of clinker and ash.

This grate is made by the Kelly Foundry, of Goshen, Ind. It is made to fit any size of furnace and with air space best adapted to the kind of fuel used. It is self-contained and does not require any alterations in the ordinary furnace to install.

Sixth Congress of the International Association for Testing Materials

The Sixth Congress of the International Association for Testing Materials will be held in New York City, at the Engineering Society's Building, 29 West Thirty-ninth Street, in the week of September 2nd to 7th. Admission will be restricted to members of the International Association and of the American Society for Testing Materials which is so affiliated with International Association, and to duly appointed delegates from foreign countries and scientific bodies.

The Congress fee is $5.00 for members and $3.00 for ladies accompanying members. Any other person may become a member of the Congress by payment of the current year's dues of the International Association for Testing Materials ($2.00) in addition to the Congress fee.

On **Monday, Sept. 2,** the headquarters at 29 West Thirty-ninth Street will be open all day for the registration of members, for the acceptance of the credentials of delegates, and for the convenience of foreigners and strangers in the city, in securing lodgings, etc.

In the evening of Monday, September 2, there will be an informal reception under the joint auspices of the American Society for Testing Materials, the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, and the American Institute of Mining Engineers. Evening dress will not be required.

On **Tuesday, Sept. 3,** the Congress will convene at 10 o'clock, at which time there will be addresses of welcome by the President of the American Society, and by National, State, and Municipal officials. The various sections will then arrange for their sessions in their respective section rooms. The section sessions will convene at 2 p. m. and continue until 5 p. m. In the evening there will be a reception by the officials of the city in the Public Library Building, Fifth Avenue and Forty-first Street. Evening dress will not be required.

On **Wednesday, Sept. 4,** section sessions will take place from 10 to 12 a. m. The afternoon and early evening will be occupied by an excursion to West Point.

On **Thursday, Sept. 5,** there will be section sessions beginning at 10 a. m. and 2 p. m. In the evening there will be a reception tendered to the foreign members by the American Society of Civil Engineers, in its building at 220 West Fifty-seventh Street. Evening dress will be in order.

On **Friday, Sept. 6,** there will be section sessions in the morning and early afternoon, and an evening excursion down the harbor.

On Saturday Sept. 7, morning, at 10 o'clock, there will be a general session at which the sections will report, and resolutions upon their recommendations will be presented. The Congress will adjourn at noon.

The Museum of Natural History will receive the Members of the Congress for Testing Materials together with those of the International Congress of Applied Chemistry at 3 p. m. The Museum of Art will receive the Members of the Congresses at 8 p. m. Evening dress will not be required.

The technical proceedings of the Congress will be unusually valuable. There are about 170 foreign and about 35 American papers to be presented.

President Taft is the patron of the Congress.

Dr. Henry M. Howe is the Chairman and Mr. H. F. J. Porter, 29 West Thirty-ninth Street, New York City, is the secretary.

Personal.

Mr. **Walter W. Davis,** manager for the Smuggler Leasing Company, at Aspen, Col., has been obliged to undergo a minor surgical operation in a Denver hospital. He is now well on the road to recovery.

Mr. **W. H. Storms,** state geologist for California, has made a professional trip to the new camp of High Grade, in northern California, for the purpose of investigating conditions there.

Mr. **Thomas H. Leggett** has severed his partnership with Mr. Fred Hellman, and has become consulting engineer for the American Smelting & Refining Company, with offices in New York. Mr. Hellman will continue in private consulting practice at 60 Broadway, New York.

Mr. **G. H. Clevenger,** metallurgical engineer, recently made a trip to Denver from California on professional business.

Mr. **Victor G. Hills,** of Denver, has returned from his recent trip to Alaska.

Mr. **Otto Wertenweiler** will have charge of the construction of the new mill being built at the Commonwealth mine, Pearse, Ariz., for the Montana Tonapah Mines Company.

Mr. **H. Kenyon Burch** has been appointed chief mechanical engineer for the Inspiration Consolidated Copper Company, which is engaged in the construction of a large concentrating mill in Arizona.

Mr. **Charles Butters** recently visited the high-grade mill of the Nipissing mines, at Cobalt. Mr. Butters is responsible for the novel features of the metallurgical process used there.

Mr. **E. L. Wolcott,** assistant secretary of the American Mining Congress, was a speaker at a meeting of Utah mining men in Salt Lake City, called for the purpose of organizing an association for mutual benefit in matters relating to mining legislation.

Mr. **A. O. Krieger** has severed his connection with the Busch-Sulzer Brothers-Diesel Engine Company, and has opened an office at 916 Victoria Building, St. Louis, for the sale of the Tacchella oil burning device, which is especially suitable for japanning and annealing ovens and for domestic heating purposes.

Mr. **H. W. Hardinge** has returned to New York from an investigation of the iron mines in northern Norway.

Prof. **Wilh. Palmaer** of the Institute of Technology of Stockholm, Sweden, has arrived in this country to attend the Congress of Applied Chemistry as the official delegate of Sweden. The time before the Congress convenes he is spending in the study of recent electrochemical developments.

Geheimrat **Dr. C. Duisberg,** of Germany, has arrived in this country and is at present in Yellowstone Park. He will attend the New York celebration of the Verein Deutscher Chemiker, of which he is president, and at the Congress of Applied Chemistry he will deliver one of the four general public lectures as the representative of Germany.

Digest of Electrochemical U. S. Patents.

Prior to 1903.

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ORE TREATMENT (*Continued*).

578,171, March 2, 1897, Charles P. Turner, of New York, N. Y.

Relates to electrolytic apparatus for the separation of metals from their ores. The apparatus comprises a tank to contain the electrolyte, a cathode, and an anode in the form of a receptacle suspended in said tank. The receptacle is preferably made in the form of a cage having its frame composed of metallic bars covered with a fabric such as hair, cotton or linen cloth and of a fineness that will keep the granulated or pulverized ore from sifting through the lining into the electrolyte. The lining, as well as the metal bars, is covered by a conducting substance which will preserve the metal and cloth from corrosion, and at the same time is a good conductor of electricity.

579,872, March 30, 1897, Joseph Henry Haycraft, of Adelaide, South Australia, assignor to The Haycraft's Gold Extraction Company, Limited, of same place.

Relates to extracting gold and silver from finely-divided ores. The apparatus consists of a heated pan having a well of mercury at the center and provided with a revolving stirrer terminating in shoes of carbon arranged so as not to meet in the center of the pan. Suitable connections are made with a dynamo, the pan being the cathode and the stirrer with its arms the anode. The process is as follows: A charge of finely-divided ore placed in the pan is covered with hot water, mercury is added equal to about 5 per cent of the charge of ore and also about 1 per cent of chlorid of sodium and about one-eighth per cent of chlorid of barium. The temperature of the contents of the pan is raised until the water commences to boil gently. The stirrer is caused to revolve slowly and a current of electricity is passed continuously through the charge to yield chlorin. The mercury is charged with gold, and the amalgam is separated in the usual way. Though described with respect to chlorin, the process answers with bromin and salts yielding bromin.

581,160, April 20, 1897, Henry Hirsching, of Salt Lake City, Utah.

Relates to a process for obtaining copper, silver and gold from ores. The apparatus consists of a lixiviation-vat provided with a false perforated bottom, also covered with burlap to obtain a good filter. I provide the top of the vat with a removable cover, and a tube is provided for supplying air or gases through the bottom. A tank below can be used for precipitating purposes, according to the sulfid method or for depositing the copper and disengaging copper by electric action. The process is as follows: A solution of ammonia or carbonate of ammonia is prepared, to which is added, if desired, nitrate of ammonia or a nitrate of an alkaline metal. The powdered crude or calcined ore in the lixiviation-vat is charged with the above solution, allowing sufficient time for a thorough mixture and for the conversion of the copper into the soluble copper salt. The metal solution is discharged from the solution into the tank; I then wash the ore with water, and a current of electricity is turned on. Pure metallic copper is deposited on the cathode.

582,077, May 4, 1897, Emanuel Motz, of Brewermine, South Carolina.

Relates to the extraction of precious metals from their ores and apparatus whereby the extraction is facilitated. A charge of ore is placed in a drum, also an aqueous solution of cyanid of potash with mercury to amalgamate the precious metal in the ore. Compressed air is then forced into the drum or receptacle to increase the pressure therein, so as to force the solution into the crevices and pores in the ore. An electric current is passed through the ore, the terminals being copper plates. The ore is subjected to the simultaneous action of atmospheric oxygen, cyanogen, mercury, and the electric current, the precious metals being deposited in the form of amalgam on one of the electrodes. The rotating drum contains a core carrying cathode plates, and also, on its inner periphery, are anode plates separated by wood shelves. These shelves serve to lift the ore during the rotation and to spill it through the compressed air, absorbing oxygen, and into the cyanid solution. When the operation is completed, the contents of the drum are washed onto a filter, the slimes subsequently being washed down a sluiceway in which the amalgam may be recovered.

584,242, June 8, 1897, Pedro G. Salom, of Philadelphia, Pennsylvania.

Relates to the manufacture of commercial lead from lead ore without the employment of heat. Lead ore reduced preferably to a powdered state is placed in a vessel, and connected with the negative pole of the dynamo. In the electrolytic fluid is an anode of a plate of lead connected to the positive pole of the dynamo. Current passing through the positive electrode and the electrolyte to the negative electrode will liberate hydrogen, which acts to reduce the metal from the ore under treatment; if the ore be a sulfid, sulfur combining with the hydrogen passes off as sulfureted hydrogen, leaving spongy metallic lead.

585,355, June 29, 1897, Charles Anthony Burghardt and Gilbert Rigg, of Manchester, England.

Relates to the recovery of metallic zinc from ores of zinc or metallic zinc and metallic copper from zinc ores containing copper or metallic copper from copper ores. The ore, whether cupriferous or otherwise, is first roasted and converted into the oxides of these metals. The ore is now crushed into powder and placed in the tank with a stirrer. A concentrated solution of ammonia or ammonium carbonate is then poured on the ore; next the surface of the liquid is covered with a layer of paraffin oil. The stirrer is now set in motion, and the oxides of zinc and copper are rapidly dissolved. The stirrer is stopped and the solution allowed to settle and suspended matter falling to the bottom may be separated by filtration.

To remove the oxides of iron from the solution, hydrated oxide of tin is added, preferably at a temperature of about 40 deg. C.; the solution is kept well agitated and in a few hours the iron is precipitated as oxide; the clear solution is run into a fresh tank, but if the ore in the first place contained copper there is placed in the tank plates of metallic zinc or zinc and tin acting as a couple. The copper begins to deposit in hard, bright scales. The solution is thus freed from copper. In the zinc-depositing tanks the solution is subjected to electrolysis and is covered, as before, with a layer of oil and maintained at a temperature of about 40-50 deg. C.

585,492, June 29, 1897, Jean F. Webb, of St. Louis, Mo.

Relates to the recovery of precious metals from solutions, such as cyanide of potassium. A filter with a series of cells or compartments is filled alternately with carbon and zinc and the solution is caused to pass in a downwardly direction through the carbon and in an upwardly direction through the zinc. The compartments when thus filled become positive and negative cells, and a solution of cyanide of potassium containing precious metals generates an active electric current and hastens the precipitation of the precious metals held in solution. It is intended that the greater portion of the precious metals held shall be deposited in the carbon, and this object is further assisted by introducing a small perforated pipe into each zinc compartment through which at intervals a strong current of compressed air is turned. This air rising through the zinc clears it of the brown powder-like deposit of precious metal, forcing the deposit upward and over with the upward flow of the solution and into the carbon. The richer upper portion of the carbon can be taken off from time to time for burning and smelting, and at long intervals a general clean-up will be necessary.

588,076, Aug. 10, 1897, Bernard Mohr, of London, England.

Relates to the treatment of ores containing the sulphides of lead and zinc and of other metals with acid sulphate of sodium. The zinc contained in these ores is converted into soluble sulphate of zinc; the pulverized ore and acid sodium sulphate, about 10-15 hundredweight per ton of ore, are fused together. The mass is then dissolved in hot water to which, if necessary, a small quantity of sulphuric acid is added. This solution is electrolyzed until most of the zinc is deposited. The liquid is then concentrated until it is of the necessary strength for fusing with a fresh batch of the sulphide ores. The insoluble residue consisting of the sulphides of lead and of other metals is refined and desilverized. Any silver present in the solution may be precipitated by usual well-known means and the zinc is then electrolytically deposited.

588,740, Aug. 24, 1897, Beda Becker, of Eupen, Germany.

Relates to the treatment of gold and silver ores for the extraction of the precious metals therefrom. Ore is crushed to the desired extent and then introduced into a vat with a solution of cyanide of potassium, which is kept in a constant state of circulation by a suitable pump. The vat is of conical shape and the circulating pump has its suction pipe connected with the top of the vat, while the discharge side is in connection with the bottom, so that the circulation is in an upward direction, thus causing a very rapid action of the cyanide to take place. Plates for amalgamating the free gold are arranged around the sides and bottom of the vat and adapted to be removed from time to time. The solution is forced in a rotary motion and thus imparts a slight centrifugal action to the particles held in suspension which tends to bring the particles into contact with the sides of the vat. When the cyanide solution is treated electrolytically the vat is combined with a second vessel in which the anodes and cathodes are suspended: the solution circulates from the amalgamating vat into the electrolytic vat and then through the pump back into the amalgamating vat. As the circulation takes place any particles of free gold will, owing to their great specific gravity and to the rotary motion imparted to the liquid, be deposited on the amalgamated plates to form an amalgam, while at the same time the fine gold and particles of gold which are combined with the gangue will be wholly or partially dissolved.

590,801, Sept. 28, 1897, Wilfred L. Brown, San Francisco, Cal.

Relates to treating rebellious ores containing precious metals by an alternating current; the precious metals being saved by amalgamation. The apparatus consists of a tank having removable amalgamating plates placed upon the interior sides and a pipe laid along the middle of the bottom of the tank, perforated with slits so that jets of water forced through them will impinge upon the amalgamating plates. The amalgamating plates are connected as electrodes and are preferably of cast iron which extend throughout the length of the tank. These plates converge downward, but do not touch, leaving circulating passages for the fluid. The ores in a finely divided state are placed in the tank and a sufficient quantity of water added to render the mass fluid. A suitable compound is placed in the tank, which exerts a chemical action on the ore. With ores having iron as a base black oxide of manganese is added; oxygen is liberated which combines with the iron, making an oxide of iron. The electric current causes the compound to separate into its constituent elements, which has affinity for the base of the ore. Chemical reaction therewith takes place, separating precious metals. A continuous circulation of the fluid contents of the tank against the amalgamating plates and then between the electrodes is maintained.

591,141, Oct. 5, 1897, Joseph W. Richards, of Bethlehem, Pa.

Relates to processes in which a metal is recovered from solution by means of electrolysis, and the main feature lies in the anode employed in the electrolysis. By way of example, the extraction of gold from a cyanide solution will be described. The apparatus consists of a tank, the bottom of which is filled with sodium amalgam. Above this is hung a series of cathodes with the amalgam as the anode. A porous diaphragm is interposed between these electrodes, dividing the tank horizontally. Through the upper of these compartments flows the cyanide solution carrying gold. The lower compartment is filled with any suitable electrolyte, such as a solution of cyanide of sodium. The electrolytic current causes decomposition of the double cyanide salt, gold being deposited and a proportionate quantity of sodium set free from the amalgam. As the process proceeds the amalgam is constantly replaced by fresh from an external source.

592,055, Oct. 19, 1897, Ernest C. Ketchum, of Boston, Mass.

Relates to a process of treating mixed sulphide ores containing lead and zinc. It consists in first roasting the ores; then subjecting the roasted ores to a solution of caustic alkali in the presence of heat to remove from the ores the lead and zinc; then subjecting the caustic solution containing the lead and zinc to electrolytic action in one or more cells to remove the lead, the anodes of which cells are immersed in a volume of pure caustic solution separated by a porous medium from the electrolyte containing the lead and zinc; then subjecting the caustic solution or electrolyte containing the zinc only to electrolytic action in one or more cells to remove the zinc.

592,973, Nov. 2, 1897, Emanuel Motz, of Brewer Mine, S. C., assignor of one-half to Henry F. Welch, of Charleston, S. C.

Relates to an improved electrolytic apparatus for the separation of metals from their ores and solutions. It consists of a series of undulatory communicating passages or channels, each having a contracted outlet and each having opposing walls composed of an anode and a cathode respectively, and forming a frame or sluice composed of any desired number of removable sections connected together. The upper face of the bottom of the frame or sluice is made undulatory or corrugated. On the curved face an amalgamated copper plate is disposed, being convex in conformity with the face of the bottom and constituting the negative electrode. The spaces between the end sections of the apparatus are made to form mercury wells, in which excess of mercury in the apparatus may collect without electrically connecting the plates of one set with those of another. The positive electrodes or anodes, preferably of lead, are placed over an eccentric to the cathode plates in the bottom of the frame or sluice. The frame is disposed in an inclined position so that the electrolyte and door will flow by gravity and will be effectually agitated without the aid of auxiliary agitating means. By contracting the outlets of the respective communicating passages, the force of the flow from one passage to the next will be increased and the agitation of the electrolyte and pulp will be proportionately augmented. In operating, the ore will first be finely divided, then mixed with a solvent and fed into a sluice (the electrical circuit having been closed). In the passage of the pulp through the apparatus the larger particles of gold will be caught mechanically by the copper plates and be amalgamated thereon. The finer particles are forced upward against the anode and thus held in the zone of intensest action of the solvent agents, thereby being quickly dissolved and carried down to the cathode by the electric current.

594,611, Nov. 30, 1897, Stephen H. Emmens, of New York, N. Y.

Relates to the removal of zinc from zinc-bearing ores, such as zinc and lead sulfids, as, for example, the zinc and lead sulfid ores of Broken Hill, Australia. The ore is first crushed to from 20 to 30 mesh. The crushed ore is roasted in a reverberatory furnace to convert the zinc sulfid into zinc sulfate.

A series of vats is provided, each having a sheet lead anode at the bottom, and a horizontal cathode plate of zinc or other suitable metal suspended in the upper portion. Each vat has an inlet extending to the bottom of the vessel and an exit pipe from the top of the vat so arranged that a flow of liquid may traverse the vats in an alternately descending and ascending manner. The vats are filled with crushed and roasted ore, and

water caused to flow through, first, vat No. 1, which in the beginning is not made a part of the electric circuit. The water dissolves the zinc sulfate, and the solution passes into vat No. 2, which is made part of the electric circuit. An electrolytic action is set up depositing metallic zinc on the cathode and setting free a corresponding quantity of sulfuric acid. The solution thus acidified flows into vat No. 3, which is not then part of the electric circuit, and becomes neutralized by dissolving zinc oxid and basic zinc sulfate. It next flows into vat No. 4, which is part of the electric circuit, where it deposits a further quantity of zinc and again becomes acidified. The flow of a solution thus alternately neutralized and acidified continues through the whole series of vats. At suitable intervals of time vats 2, 4, etc., are cut out of the electric circuit and the electric current is caused to pass through vats 1, 3, etc. This change is effected by suspending each neighboring pair of cathodes from the vats of a metallic beam, pivoted in the center. By turning the beam on its pivot, one cathode is depressed in the solution to the vat to which it belongs and the cathode at the other end of the beam is raised out of the solution in its vat, thereby closing or opening the electric circuit in either vat.

The flow of the solution is continued and the electric current changed from vat to vat until the metallic zinc is deposited and the zinc sulphate in the solution amount together to a quantity showing that the zinc-contents of the ore have been removed sufficiently to render the residual ore fit for smelting.

BOOK REVIEWS.

Higher Mathematics for Chemical Students. By **J. Riddick Partington**, B. Sc. 12mo, 272 pages, 44 diagrams; price $2.00 net. New York: D. Van Nostrand Company.

A short but trenchant introduction shows the author to have very clear-cut and fruitful ideas of the function of mathematics in chemistry. He believes it "clear, however, that the distinguishing of the whole development of theoretical chemistry and physics is the elimination of the anthropomorphic elements, especially specific sense-impressions, from the concepts." Starting from this, he proceeds to elaborate the fundamental principles of higher algebra, geometry, and the calculus in terms of number and quantity, fixed, progressive and continuously changing, as illustrated in the fundamental facts of chemical statics and dynamics. The thesis is worked out very satisfactorily; it will be a useful text-book for chemical students, and may give new points of view and excite a fresh interest among the older generation of chemists.

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Chemical Arithmetic and Calculation of Furnace Charges. By **Regis Chauvenet**, LL.D. Octavo (15 x 23 cm.), 302 pages; price $4.00. (Philadelphia: J. B. Lippincott Company.

The book is in two distinct parts; the first 200 pages forms an elementary statement of the principles of chemical calculations, the other 100 are concerned with the application of these to smelting ores and forming slags. The first part is similar to numerous text-books of elementary chemical calculations previously published, except that it is elementary to the verge of peurility; it is a chemical A, B, C and first primer. Students, who need such pedagogical coddling must be in reality veritable mental weaklings. This mental flabbiness, if it is a fact, damns our elementary educational system, and proves the urgent necessity of more *virile* tone and teaching in our elementary schools.

As for the last third of the book, the technical part, it is concerned with smelting of ores, principally smelting to matte, and gives for a student or a practical furnace man a clear and useful knowledge of the subject. The author is quite right in advising the abandoning of calculations of *excess* silica or base when figuring out a furnace charge; but the method of valuing fluxes or ores by excess lime or excess silica per unit weight is of importance for comparing the values of different materials for the furnace, and should be taught in that connection. This part of the book is elementary, but also goes thoroughly into the subject; it is the outcome of much practical experience and is a valuable contribution to metallurgical literature.

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Annual Tables of Constants and Numerical Data, Chemical, Physical and Technological. Compiled and published by an International Commission appointed by the Seventh International Congress of Applied Chemistry, under the patronage of several governments, scientific societies and individuals. Vol. I, 1910. Large quarto, 22 x 27 centimeters, 727 pages, price $6.00, postage, $0.54 extra. Chicago: University of Chicago Press, 1912.

This patiently-awaited volume fulfills all expectations; in fact, it exceeds them. Nearly 300 scientific publications of 1910 were read by over 150 scientists (most of them men of international reputation), and the result is a work such as could have been achieved in no other possible way. It seems to us as nearly perfect as anyone has a right to expect.

It must be clearly understood that this is not a complete tabulation of constants *to date*, but only a compilation of such as were published as *new* in 1910. Volume II will be a similar review of 1911. The work informs the scientist of *new* determinations; it does not mention the older ones. For data previous to 1910, standard tables, such as Landolt-Börnstein-Meyerhoffer, must be used. This work *supplements* such tables.

It is the intention to publish in Volume II an alphabetical reference index of all subject matter in both volumes, and to continue such a complete index in each succeeding volume. This is to decrease the labor of searching through several large volumes to find the information one seeks. The difficulty is real, but the remedy proposed is a makeshift which will not give complete satisfaction.

We have a more radical remedy to submit to the commission. It is as follows: What the scientist needs and should have is a hand-book of *complete* data revised as frequently as practicable; too many supplements are a weariness to the flesh. A combination is necessary; a good set of tables should be taken as the basis, and every five years, let us say, it should be revised to date.

To be more specific, let us suggest that it should be practicable to arrange with the publishers of the Landolt-Börnstein-Meyerhoffer Tabellen to put them into the hands of the International Commission in 1915, so that volume V of the "Annual Tables" shall be a complete revision and compendium of "Constants" to that date. Thus volumes I, II, III and IV will have served the very useful purpose of furnishing us with the newest data until the revision of the "Tables" appears, and then the labor of using five volumes will be dispensed with by the possession of the one revised edition. Volumes VI, VII, VIII and IX would be again "Annual Tables," while Volume X, for 1920, would be another revised set of "Tables." This is a scheme which can be worked for a century, whereas "Annual Tables" only, every year for a century, would be a waste of paper and ink; the "Annual Table" system decreases in usefulness each year, and eventually will break down of its own weight.

The remedy is the revision of a standard set of tables every five years.

The above is not meant for criticism of Volume I; it is beyond criticism. But Volume I is part of a system which, to reach its highest usefulness, should be planned so as to include the periodical issue of complete "Tables," worked over with as great thoroughness as the "Annual Tables." Then will the chemist and the physicist be indeed magnificently provided with complete data in the most available and practical form.

J. W. Richards.